

## X. NOTES UPON THE FAMILIES AND GENERA OF THE NAJADES.

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(Plates XVIII-XX.)

In accordance with the observations recorded in a number of shorter notes on the *Najades* published recently by the writer (Ortmann, 1910a, 1910b, 1910c, 1910d, 1911a) it is evident that the system of Simpson (1900b) should be thoroughly revised, and that the soft parts of every species of mussels should be studied. In preparation for a monograph of the *Najades* of Pennsylvania this has been done by the writer, and the general results have been recently published in the first part of this work (Ortmann, 1911b). But since it will take some time before the subsequent parts, dealing with the single species, will be ready for publication, and since the writer has examined, in addition, a great number of species not found in Pennsylvania, it seems well to publish these results as early as possible, combining the same with an attempt to rearrange the system to suit the new points of view. In the present paper, a general synopsis of the system will be given, in it assigning to each species, which has been examined, its proper place.

*Remarks as to the Figures.*—For the majority of the genera, text-figures have been introduced to illustrate their principal characters. If possible, the type-species has been selected. These figures have been drawn from actual specimens, and are about natural size, but they have been generalized and are of a diagrammatic character, the chief features being emphasized. This refers chiefly to the gill-filaments (where they are given, as in the *Margaritanidæ*) and the septa. The latter always are heavier than in nature, to bring out their characteristic features. In all figures the lettering is uniform, and the letters have the following meaning:

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|---------------------------------------|--|
| <i>an</i> = anal opening;             | <i>o</i> = outer gill;                   |
| <i>br</i> = branchial opening;        | <i>p</i> = pes (foot);                   |
| <i>f</i> = flaps of margin of mantle; | <i>pp</i> = papillæ on margin of mantle; |
| <i>i</i> = inner gill;                | <i>sa</i> = supra-anal opening.          |
| <i>mp</i> = marsupium;                |  |

The main figure always represents the soft parts seen from the left side, with the left half of the mantle removed.

The *Najades* have been divided into three families: *Margaritanidæ*, *Unionidæ*, *Mutelidæ*. The first is holarctic; the second is known from Eurasia and North America, but probably exists also in Africa; the third is restricted to Africa and South America.<sup>1</sup>

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Family I. MARGARITANIDÆ Ortmann.

Diaphragm incomplete, formed only by the gills: outer lamina of outer gills only in part connected with the mantle, posteriorly free for a considerable distance. Anterior end of inner gills separated from the palpi by a wide gap. The margins of the mantle do not unite or approach each other anywhere, and there is no tendency to form branchial and anal siphons, and no supra-anal opening is present. Gills without water-tubes, interlamellar connections irregularly scattered, or forming irregular, oblique rows, or incomplete septa, which run obliquely to the direction of the gill-filaments. Marsupium formed by all four gills. Glochidia small, semicircular and globular, without hooks, but with irregular small teeth at the ventral margin.

Family II. UNIONIDÆ Swainson (*restricted*).

Diaphragm complete, formed only by the gills: the outer lamina of the outer gills connected with the mantle at its posterior end. Anterior end of inner gills separated from the palpi by a more or less wide gap. Margins of the mantle drawn together by the gill-diaphragm, but not united, thus separating the anal from the branchial opening, and the anal is generally closed above by the union of the margins of the mantle (it rarely remains open), and, when closed, it always leaves a supra-anal opening (which is very rarely obliterated). Gills always with water-tubes, formed by interlamellar connections developed as continuous septa, running parallel to the gill-filaments. Marsupium formed by all four gills, or by the outer gills alone, or by parts of the outer gills. Glochidia of various shapes, suboval, subtriangular, or celt-shaped, with or without hooks on the ventral margin.

<sup>1</sup>The writer is convinced that the *Najades* will prove to be a most important group for the reconstruction of the ancient geographical features of the earth. As long as our knowledge of the systematic relations was obscure, or even directly wrong, any attempt in this direction must have been a failure.



This family is divided into three subfamilies, as follows:

1. Subfamily UNIONINÆ Ortmann.

Rarely no supra-anal opening formed, it is generally present, separated from the anal opening by a shorter or moderately long mantle-connection. Marsupium formed by all four gills or by the two outer ones, when charged, only moderately swollen, and its edge not distending. No secondary water-tubes developed within the marsupium. Glochidia rather small, or of medium size, subovate, without hooks; or subtriangular, with hooks.

2. Subfamily ANODONTINÆ Ortmann.

Supra-anal opening always well separated from the anal opening, often by a very long mantle-connection. Marsupium formed only by the two outer gills, when charged, greatly swollen, and an extra thickness of tissue at the edge permitting the gills to distend. Within the marsupial gill, the water-tubes are divided during the breeding season into two lateral (secondary) water-tubes lying toward each face of the gill, and a central ovisac, which is closed at the base of the marsupium. Glochidia rather large, subtriangular, with hooks.

3. Subfamily LAMPSILINÆ Ortmann.

Supra-anal opening always separated from the anal opening by a mantle-connection of medium length, rarely entirely closed. Marsupium formed by the two outer gills, or by parts of the latter, generally situated in their posterior portion. When charged, the marsupium extends beyond the original edge of the gill, an extra thickness of tissue at the edge permitting a bulging out. Water-tubes of marsupium not subdivided, when charged. Often special structures (papillæ or flaps) on the edge of the mantle, chiefly of the female, in front of the branchial opening. Glochidia of various sizes and shapes, small to rather large, either subovate, without hooks, or celt-shaped, with two spines on each valve.

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Family III. MUTELIDÆ Gray (*emended*).<sup>2</sup>

Diaphragm complete, formed anteriorly by the gills, posteriorly by a firm union of the margins of the mantle. Anterior end of inner gills

<sup>2</sup> As has been stated in a previous publication (Ortmann, 1911a), the nomenclature of this family and its subfamilies is only provisional, until additional genera (chiefly *Mutela* itself) have been investigated.

in contact with the palpi. Branchial and anal siphon sharply separated by the union of the margins of the mantle. Anal opening open, or closed above, in the latter case without forming a supra-anal opening. In some genera the margins of the mantle unite also in front of the branchial opening. Gills with very indistinct intercommunicating water-tubes, and interrupted interlamellar connections; or with well-developed water-tubes and septa, parallel to the filaments. Marsupium formed only by the inner gills. The larvæ are glochidia or lasidia.

This family is divided into two subfamilies.

1. Subfamily HYRIINÆ Ortmann.

Anal opening closed above. Marsupium with septa-like, interrupted, interlamellar connections, forming incomplete, communicating water-tubes. Non-marsupial gills with poorly developed interlamellar connections. Larva a glochidium.

2. Subfamily MUTELINÆ Ortmann.

Anal opening open or closed. Marsupium with well-developed, continuous septa, forming well-defined water-tubes; also non-marsupial gills with septa and water-tubes. Larva a lasidium (?).

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There is no doubt, that of these three families that of the *Margaritanaidæ* is the most ancient; the lack of any tendency to form siphons, the incomplete diaphragm, the absence of real septa and water-tubes in the gills, the absence of a division of function in the gills (all four gills in the female are used both for breathing and for receiving the eggs), are peculiarities, which establish the primitive character of this family.

The forward step in the development of the *Unionidæ* consists chiefly in the specialization of the marsupial structure. In the most primitive forms, all four gills are used as marsupia, but later on a division of labor is effected, so that in the female some gills serve only the purpose of respiration, while others, or parts of them, become organs used in propagation. But always, in this family, the inner structure of the gills is more complex than in the *Margaritanaidæ*, which is expressed, by the development of septa and water canals;<sup>3</sup>

<sup>3</sup> In *Margaritana monodonta* a slight tendency is shown to develop septa, but here the septa are entirely different from those of the *Unionidæ*, not running parallel to the gill-filaments, as in the latter, but diagonally to them.

and secondly by the fact that the structure of the marsupium in the *Unionidæ* becomes highly specialized, or, to express it concisely, this family makes a special effort to bring the marsupial apparatus to the highest degree of efficiency. All differentiation is connected with two purposes: the lengthening of the breeding season, and the change of the discharge of the glochidia from a "natural" to an "unnatural" manner, if such an expression may be allowed. As regards the first, the subfamily of the *Unioninæ* is as yet in an undifferentiated condition, possessing a short breeding season (being *tachytictic*), without specialization.<sup>4</sup> But in the *Anodontinæ* and *Lampsilinæ* the breeding season is extended over the winter and the glochidia, after they are fully developed, are not discharged immediately, but retained for a long period in the marsupium (*bradytictic*). This renders it necessary to develop special devices in the marsupium, and the most urgent need apparently is to provide the necessary oxygen for the glochidia enclosed in the marsupia. It is now interesting to observe how this purpose is accomplished in two different ways by the two subfamilies. In the *Anodontinæ*, the lateral, secondary water-tubes cut off from the central ovisac, undoubtedly have the purpose of keeping up a lively current of water around the swollen marsupial mass. Nothing similar to this is known in the *Lampsilinæ*, but in the case of these the whole marsupium bulges out beyond the original edge of the gill, and this bulging mass is enclosed in a rather thin membrane, favoring osmotic processes. Further, there is a tendency to locate the marsupium in the posterior part of the gill, and to push it toward the lower posterior end of the shell, so that it is close to the branchial opening, where fresh and pure water enters the animal. In addition, a number of the *Lampsilinæ* develop special papillæ and flaps on the edge of the mantle, just at the place toward which the marsupium is pushed, and these structures surely have the purpose of producing a lively current of water over the marsupium. Furthermore, the thin membrane enveloping the protruding part of the marsupium, and its position near the branchial opening, are apparently connected with the peculiar discharge of the glochidia in the *Lampsilinæ*, which is through the edge of the marsupium, through holes

<sup>4</sup> Haas (1910e, p. 19) comparing the marsupium of *Anodonta* and *Unio* expresses the opinion that that of *Anodonta* is more primitive than that of *Unio*, which is entirely erroneous: just the opposite is the case, that of *Anodonta* being much more complex and specialized. As long as views like this prevail, we cannot expect to arrive at a proper understanding of the system of the *Najades*.

which form there for this purpose. This "unnatural" discharge is known only in the *Lampsilinæ*, and is unknown in the *Anodontinæ* and *Unioninæ*. Finally the family of the *Unionidæ* differs from the *Margaritanidæ* and is more highly advanced in the formation of rudimentary siphons. But in this respect this family is not very progressive. It has the anal and branchial openings separated only by the (complete) gill-diaphragm, and in addition, it has the anal closed above, thus giving it an incomplete tubular shape. Beyond this, there is no progress in this family. The presence of a supra-anal opening is, in my opinion, only incidental to the closing of the anal.

The members of the third family, the *Mutelidæ*, have gone in another direction in their development. If the expression may be permitted, they lay chief stress upon the better development of the siphons, while in the differentiation of the gill-functions they have started out from the beginning with another idea, which, however, has not attained a very high degree of perfection. With regard to this it may be said that they have restricted the marsupial function to the inner gills, and very likely the anterior connection of these gills with the palpi is incidental to this function. Not much advance is to be observed in the gill structure, and only two types are met: incomplete septa and intercommunicating water-tubes (a rather primitive condition) in one group (*Ilyriinæ*); and complete septa and water-tubes in the other group (*Mutelinæ*). Very likely the latter structures are not homologous to the septa and water-tubes of the *Unionidæ*, but have been acquired independently, since their finer structure is different. With regard to the siphons, which attain within this family their highest perfection among the *Najades*, we have first of all a complete separation of anal and branchial openings by a firm mantle-connection, which forms the posterior continuation of the gill-diaphragm, and in addition we have a tendency to close both the anal above, and the branchial below, by mantle connections. It is true that this tendency is not yet perfect in many *Mutelidæ*, but it is developed within this family, so that in the most highly specialized genera we have two real-tubular siphons, formed by complete coalescence of the edges of the mantle.

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I think the above account of the phylogenetic tendencies within the various divisions of the *Najades* will make it clear that the morphological characters upon which our new system is founded are

characters which are *essential*, since they indicate the various "ideas" in the specialization within each group, and advance our understanding of the phylogenetic progress and the systematic affinities of the *Najades*.

It may not be amiss to point out that it is absolutely impossible to recognize this system in the characters of the hard parts, the shells. It is true that certain types of shell are characteristic within smaller groups, and that there are cases, where we are able to recognize a genus, for instance, by the shape of the shell. But if we come to compare the subfamilies and families, we find that various types of shell turn up in them again and again. This goes so far that certain species resemble each other so much externally that they have been confused or placed together even by our greatest authorities, while they actually may belong to entirely different groups according to the soft parts. For this reason I have deliberately omitted to give shell characters for the families and subfamilies, for this is simply impossible.

One character of the shells, however, may be of greater value, and this is the *beak-sculpture*. As will be seen below, I shall use it repeatedly for the definition of genera. But it has been largely misunderstood, and is even now not very clear. Simpson, in distinguishing a concentric and a radial beak-sculpture, made a great mistake in uniting under the latter two types of sculpture, the radial and the zig-zag, while he united the double-looped with the concentric sculpture. According to my studies, which, however, are not yet fully satisfactory, the following seem to be the real conditions: The original and simplest beak-sculpture consists of *concentric* bars. A few (one to two) of them are, when the beaks are well preserved, always present, even in zig-zag or radially sculptured beaks. In many forms other bars of the same character are added, and no complications are observed. In other forms the later bars become *double-looped*. This character is generally inaugurated by the fact that the posterior part of the simple bar, which lies upon the posterior ridge of the shell, is emphasized. It becomes more pronounced, often tuberculiform, and is drawn out in the direction of the posterior ridge, toward the lower posterior angle of the shell. This produces an angular projection in the posterior part of the original bar, which by contrast with the anterior part, which does not project, gives the appearance of the bar consisting of two parts, or two loops, till we finally come to a beak-sculpture which distinctly consists of a double loop, the two parts

separated by a distinct reëntering angle. In some forms these two parts become tuberculiform, and the connecting bars disappear, so that the beak sculpture appears composed of isolated tubercles (*Unio pictorum*). A further step in advance is that the anterior part of the double-looped bar breaks up into tubercles, and finally into zig-zag bars. The manner in which this is accomplished remains yet to be studied, but always, in the zig-zag sculpture, the posterior loop, which lies upon the posterior ridge, is the most conspicuous part of the whole beak sculpture. Thus the zig-zag sculpture is the most extreme condition of a line of development, which goes from the simple concentric bar, through the double-looped, to the zig-zag condition. In certain forms with zig-zag sculpture, all three stages are clearly present on the same shell (*Nodularia douglasiae*), and possibly this may be observed always in such cases.<sup>5</sup>

Entirely different from this is the *radial* sculpture, but I have reason to believe that it also goes back to the concentric type. At any rate, I have seen in specimens of the genus *Lamellidens* that there are also originally one to two simple concentric bars. But after these only the lateral parts of the bars, which anteriorly and posteriorly curve up toward the beak, are developed, while the middle part upon the disk becomes obliterated. Then these lateral parts, which have a direction from the beak toward the basal margin, are emphasized, developing more strongly, and their direction remaining a radial one. Since there are two groups of radiating ridges (an anterior and a posterior), the median ones naturally must interfere with each other upon the middle of the disk, and must come in contact there at a more or less sharp angle, when fully developed. This is in fact the case, wherever we see radial sculpture well developed. There are always two sets of radiating folds or ridges, one originating in front, the other behind the beak, which cover the disk interfering with each other in the middle of the shell. In some cases, however, this is not very clear, and such cases possibly present the highest type, with the original features obliterated. The radial sculpture is another extreme standing at the end of a line of development starting from simple concentric loops.

These conditions are worthy of being studied more closely. In regard

<sup>5</sup> In certain cases it seems that double-looped sculpture may again be simplified by the re-entering angles becoming less sharp and only sinuate in the latest bars. But this is surely a sign of the incipient obliteration of sculpture.



to its systematic value, the beak-sculpture, when properly understood, indicates certainly systematic affinity, but is not fit to be used for the distinction of larger groups, since it is very likely that the different types were developed rather early, and are found side by side among the more primitive groups of *Najades*, the *Unioninæ* for instance. Yet in the more advanced groups often only one type is found. Thus, for instance, among the *Anodontinæ* and *Lampsilinæ*, we possess only the first type up to the double-looped structure, while the zig-zag structure is practically absent, and no trace of the other type (the radial) is ever found. On the other hand, it seems that in the *Mutelidæ* only the radial type is present, provided there is any sculpture at all. In addition, conditions become yet more complex by the fact that the beak-sculpture in general seems to be a character which is subject to obliteration, and anywhere within the system we may expect to meet forms which have reduced their beak-sculpture to a lesser or greater degree, often to complete disappearance. Thus we may say, in a general way, that beak-sculpture, although important and indicating the minor affinities, is unfit to be used for the distinction of the larger groups.

#### Family MARGARITANIDÆ.

I recognize only one genus in this family, to which a number of species have been assigned by Simpson, of which, however, the structure of four only is known.

Genus MARGARITANA Schumacher, 1817

Simpson, 1900*b*, p. 674.

#### *Margaritana margaritifera* (Linnæus).

Some twenty specimens are at hand, from the drainage of the upper Little Schuylkill River in Schuylkill County, Pennsylvania, collected by myself; soft parts of another specimen from the Auma creek, near Weida, Saxe-Weimar, Germany (drainage of Elster river); and three complete specimens from the Perl-Bach at Postfelden, near Falkenstein, Bavarian Forest, Germany. For these German specimens I am indebted to Mr. W. Israël.

Published figures: Photograph of soft parts in shell, by Carl (1910, pl. 4, figs. A and B); of gills, by Ortmann (1911*b*, p. 285, fig. 1, and pl. 87, fig. 11).



I have found that the German specimens agree in every particular with the American form. Certain characters not observed in my specimens (marsupium and glochidia) I have gathered from the literature (chiefly Harms, 1907 and 1909).

Margins of mantle free all around from the anterior to the posterior end and with no tendency to unite anywhere. Branchial opening indistinctly separated from the anal, a horizontal ridge running from the posterior insertion of the outer lamina of the outer gill to the margin of the mantle, but the margins of the mantle are not held together by the diaphragm. Anal opening not closed above, and no supra-anal

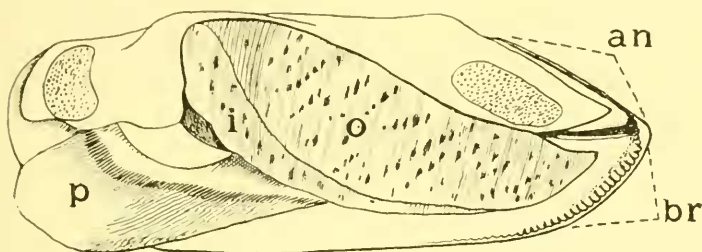


FIG. 1. *Margaritana margaritifera* (Linnaeus). Specimen from the Perl-Bach, Postfelden, Bavarian Forest, Germany. (Carn. Mus., No. 61, 4,987.)

formed. Branchial opening ill-defined anteriorly, on the inner edge with strong papillæ, which disappear anteriorly, and then the inner edge of the mantle is smooth. Inner edge of anal opening almost smooth.

Palpi large, subfalciform, drawn out and pointed behind, their posterior margins united for about one-half to three-fourths of their length.

Gills long and broad, the inner the wider, chiefly so anteriorly. Outer gill becoming gradually narrower in front, its anterior end at the highest point of the line of attachment of the mantle, high above the palpi. Inner gill narrowing more suddenly anteriorly. Its anterior end is found in front and below that of the outer gill, but separated from the palpi by a wide gap.<sup>6</sup> Edge of inner gills with a longitudinal furrow, which is absent in the outer gills (this character is present in all *Najades* examined, and will not be mentioned again).

<sup>6</sup> This character is variable, and sometimes (as in the specimen which served as original for our figure) the gap is rather short.

Outer lamina of outer gills not entirely connected with the mantle, but its posterior part is free for about one-fourth, or slightly less, of its length. Inner lamina of inner gill free from the abdominal sac with exception of its anterior end. Behind the foot, the two inner laminae of the inner gills are connected. Thus the diaphragm (separation of branchial and suprabranchial-cloacal cavities) is formed only by the gills, and it is incomplete posteriorly, and does not reach the margin of the mantle, although the medially united free ends of the gills project to near the margin of the mantle.

Gills without water-tubes and without septa. The interlaminar connections are patch-like, irregular in shape and position, and only here and there a diagonal arrangement, from the base toward the edge and forward, is indicated, which, however, does not follow the direction of the gill-filaments, and does not form continuous septa.

Color of soft parts grayish, inclining to blackish. Foot brown, paler on edge; through the middle runs a black band, sharply marked off from the whitish abdomen, but gradually shading into the brown of the foot. Gills brownish-gray anteriorly, shading to black posteriorly. Mantle brownish-white, edge black, broadly so behind. From the posterior end of the attached part of the outer lamina of the outer gill there runs to the posterior margin of the mantle a white line, bordered below with black.

No gravid females are at hand, and thus the writer cannot say anything about the marsupium and the glochidia. However, these have been described by others (see Harms, 1907 and 1909). The marsupium is formed by all four gills,<sup>7</sup> and the glochidia are very small (0.0475 mm.), semicircular, globular, without true hooks, but with a number of small teeth on the ventral margin.

The breeding season in Pennsylvania is in June and August (Conner, 1909, p. 112), in Germany in July and August (Harms, 1907, p. 814), and probably twice in succession during this time (Harms, 1909, p. 332).

### **Margaritana sinuata (Lamarck).**

The anatomical structure of this species has been described by Haas (1910b, p. 181), who created for it the new genus *Pseudunio*. Although

<sup>7</sup> Simpson (1900b, p. 674) says that the marsupium is formed only by the outer gills, and refers (footnote 2) to von Wahl. I have consulted this paper (Wahl, 1855), but cannot find in it anywhere a description or mention of the marsupium of *Margaritana*.

Haas omitted to say anything about the gill-structure, his description of the margins of the mantle, of the diaphragm, and other parts renders it absolutely certain that this species must be placed in the family *Margaritanidæ*. Haas points out certain differences from *Margaritana margaritifera*, of which the most important is the fact that the shell has lateral hinge-teeth. Since we have other genera among the *Najades* in which the hinge-teeth are variously developed, and since it is absolutely clear, that *Margaritana margaritifera*, without lateral teeth, must have descended from forms with such teeth, I think the differences in *Unio sinuatus* should be regarded as only of specific value, and I see no reason why we should not place it with *Margaritana*, with which some of its most essential and important characters are known to agree, while all the known differences are such as in other groups are known to be of minor value.

*Margaritana sinuata* thus would represent a somewhat more ancient type than *M. margaritifera* (see Ortmann, 1911c, p. 6).

#### ***Margaritana monodonta* (Say).**

I have received, from B. Walker, one complete specimen, and the soft parts of three others, all from the Cumberland River in Pulaski, Russell, and Cumberland Counties, Kentucky.

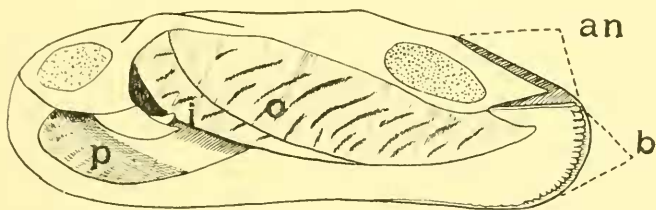


FIG. 2. *Margaritana monodonta* (Say). Specimen from Cumberland River, Rowena, Russell Co., Ky. (Carn. Mus., No. 61, 4,960.)

We may compare the description of the soft parts by Lea (Obs., X, 1863, p. 422), which, however, mentions among the important features only the posterior end of the gills, the branchial and anal openings.

Margins of the mantle, branchial and anal openings as in *M. margaritifera*. No supra-anal present. Posterior margins of palpi connected for about one-third of their length. Gills rather long (corresponding to shape of shell), the inner the wider, chiefly so ante-

riorly. Anterior ends of the two gills as in *M. margaritifera*. Outer lamina of outer gill not entirely connected with the mantle: posteriorly a part of it is free (about one-seventh of length of gill, but probably more, since this part in all my specimens is considerably contracted). Inner lamina of inner gill as in *M. margaritifera*, and thus the structure of the diaphragm is essentially the same.

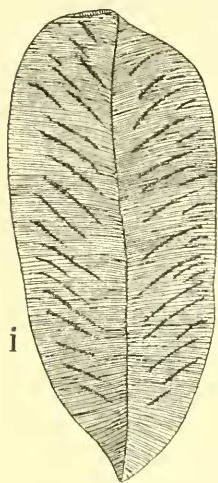


FIG. 2a. Left gills of another specimen from same locality.

Both gills are quite delicate. The two laminae are not connected by septa running parallel to the gill-filaments, but the interlaminae tissue forms septa of another type: they run obliquely, diagonally, from the base of the gill downward and forward. Of these septa some are longer, others shorter, and toward the edge of the gill they sometimes curve a little in the direction of the filaments. The septa thus are rather irregular, and being quite distant from each other, no regular water-tubes are formed.

A difference in the arrangement of the septa, which might be due to sex, could not be observed in the specimens at hand. None of them was gravid, so that nothing can be said about the arrangement of the ova in the gills, and about the glochidia. The fact, that in all specimens the structure of the two gills is practically identical, suggests, however, that all four gills are used as marsupia.

Color of soft parts whitish, edge of mantle blackish all around, but chiefly at the anal and branchial openings. Gills transparent, but not blackish. Foot grayish-white in its distal part, this gray color marked off in a sharp line from the basal white part.

*M. monodonta* agrees in most characters with *M. margaritifera*, and chiefly in the general form of the margin of the mantle, the branchial and anal openings, the diaphragm, and the structure of the gills. The chief difference is found in the diagonal, incomplete septa of the gills, which, however, unmistakably correspond to the irregular diagonal rows of interlaminae connections in *M. margaritifera*. In this respect, *M. monodonta* represents a stage of development slightly more in advance of that of *M. margaritifera*, and this would support the view

expressed by Walker (1910a, p. 137) that it is an "offshoot of the more ancient *margaritifera*-stock." In its general appearance it looks rather like a depauperated form, while the gill-structure has attained a slightly higher stage of differentiation. It also differs slightly in the lesser development of the papillae of the branchial opening, and the great reduction of the black color suffusing most of the soft parts of *M. margaritifera*, and, of course, also in shell characters. If we should accept the genus *Pseudunio* proposed by Haas for *U. sinuatus*, we would have, as a simple logical consequence, to create a new genus for *M. monodonta*, for the difference of the gill-structure of the latter is much more important than any of the differences known in *M. sinuata*. It represents a phylogenetic step in advance. But having to deal only with four species, I see no reason why we should not leave them together in the genus *Margaritana*.

***Margaritana hembeli* (Conrad).**

Eighteen specimens from Hunters Creek, Evergreen, Conecuh Co., Alabama, have been investigated. They were collected by H. H. Smith on February 10, 1911.

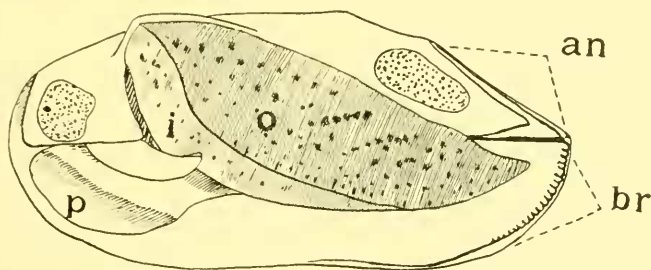


FIG. 3. *Margaritana hembeli* (Conrad). Specimen from Hunters Creek, Evergreen, Conecuh Co., Ala. (Carn. Mus. No. 61, 5,022.)

Margins of mantle, branchial and anal openings, and gills much as in *M. margaritifera*. Papillae of branchial rather small. Posterior margins of palpi connected for about three-fourths of their length.

Interlaminar connections of gills irregularly scattered, here and there with a tendency to fall into oblique, irregular rows. On the whole this tendency is less developed than in *M. margaritifera*, but there is some variation in this respect in different individuals. I was unable to dis-

cover any marked differences in the structure of the gills which might be due to sex. No gravid females were found.

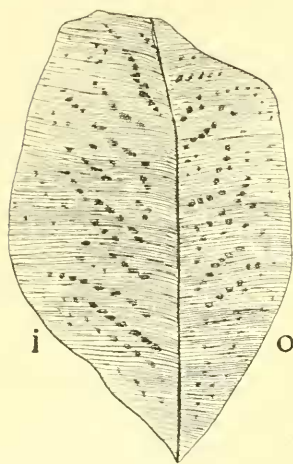


FIG. 3a. Left gills of another specimen from same locality.

Color of soft parts brownish-white; foot grayish-brown, the darker part suddenly marked off in a sharp line from the white abdominal sac; palpi and gills brownish, the latter more grayish posteriorly; mantle pale brown, its margin whitish with brown-black edge, most intense posteriorly; a black line on mantle separating anal and branchial cavities.

This is a true *Margaritana*, much resembling in structure *M. margaritifera*. But it has well-developed lateral hinge-teeth, and thus must be considered as a more primitive type. It has no closer relationship with *M. monodonta*, and cannot be connected with it. In shell-sculpture, *M. hembeli* is quite unique. Its distribution (in southern Alabama and Louisiana) offers a very interesting problem.

#### Family UNIONIDÆ.

##### Subfamily UNIONINÆ.

Simpson's (1900b) North America genera: *Quadrula*, *Tritogonia*, *Pleurobema*, and *Unio* belong to this subfamily. Further, I have shown (Ortmann, 1911c) that the European *Unio* also belongs here, as well as the Asiatic genera *Parreysia* and *Lamellidens*. I have further demonstrated, that the European *Unio* is not identical with the North American *Unio*, and that for the latter the generic name of *Elliptio* should be used. The genus *Tritogonia* is simply a synonym of *Quadrula* in Simpson's sense (see Sterki, 1907, p. 48, and Ortmann, 1911b, p. 329).

In the structure of the soft parts there is not much differentiation in all these forms. The most important is that in some all four gills are used as marsupia (see Plate XVIII, fig. 1), in others only the two outer ones (see Plate XVIII, figs. 2, 4, 5). The systematic value of this character has been doubted (see Frierson, 1909, p. 107). Yet I believe



that it is of prime significance. In all my investigations I have never come across an exception or variation in the marsupium. It is true that in species which have normally all four gills marsupial, sometimes only two gills are found *charged*. But all authors, who record such cases, only mention the fact that the gills were charged, without saying anything about the *structure* of the gills. I have also met with such cases: but invariably a closer investigation revealed the fact that the other gills which were not charged also possessed marsupial structure, and consequently were *capable* of being charged with eggs.

On the other hand, in those cases, where the outer gills alone serve as marsupium, it was not the simple fact that they alone were filled with eggs in the breeding season, which was ascertained. It was the investigation of the structure of the gills, which induced me to judge the character of the marsupium. Lefevre and Curtis (1910, p. 83) are inclined to regard my observations in *Pleurobema coccineum* as due to accidental conditions. But this is surely not so. I have seen now a great number of individuals of this species with the outer gills alone charged, and I have seen and examined many more, females in the sterile condition, which invariably had marsupial structure only in the outer gills, while the inner gills were different, and not built to receive eggs. Not a single exception was observed.

Further it is quite evident that the arrangement of four gills serving as marsupia is found in a number of groups, the species of which are undoubtedly closely allied. This is clear in the peculiar *Quadrula plicata*-group, in the *metanevra*-group and others. Then again, a marsupium formed by the outer gills alone is characteristic of other natural groups. To me the most interesting case was that of *Pleurobema coccineum*. Here I discovered first that this supposed *Quadrula* differs from the *Quadrula*-type; I also discovered that this species intergrades with *Q. obliqua* and *Q. pyramidata*. This being the case, I concluded that the latter also should have a marsupium like *coccinea*. And this proved to be true!

Nevertheless the character of the marsupium should not be too implicitly relied upon. There is no question that the condition in which the four gills serve as marsupia is more primitive than the stage where only the outer gills are marsupial.<sup>8</sup> But it seems to me that

<sup>8</sup> The functional and morphological progress from the four-gill-marsupium to the two-gill-marsupium has been correctly understood and expressed by Haas (1910c, p. 19).



there is or has been a general tendency to restrict the marsupium to the outer gills, and that this forward step in a quite natural direction has been made independently in various groups. That is to say, the *Unio*-type of marsupium has repeatedly developed from the *Quadrula*-type by parallel evolution.

Of the other features of the soft parts only three furnish some help for the distinction of genera. The first and most important is the character of the placenta, revealing differences which are of prime value, but affect only a few forms, as will be seen below. The second is the separation of the anal and supra-anal openings. Although characteristic of certain forms (in one case these openings are not at all separated), it is somewhat variable in others, even individually. Thus we can use this character only to a limited degree. The third is the connection of the inner lamina of the inner gills with the abdominal sac. Here there seems to be a difference between certain forms of the Old and the New World. But, unfortunately, too few of the former are known for me to express a final judgment.

Thus the soft parts alone would furnish only few criteria for the distinction of genera, and we should direct our attention to the shell. Here we have indeed great variety, and the shapes of the shell have been largely used heretofore for the definition of genera. The most important feature, in my opinion, is the beak-sculpture, which, however, has been largely misunderstood by Simpson. In fact in this primitive subfamily we have, side by side, all the different types of beak-sculpture, and, as we shall see, they may be used to great advantage.

Since various types of shell-structure are frequently combined with various types of soft parts, it would not do to make only a few large generic divisions. For if we recognize, for instance, only two main genera according to the character of the marsupium, the same types of shell would turn up in either of them, which surely would give an incomplete or wrong impression of affinities. Thus, in my opinion, it is advisable to admit a larger number of genera founded upon both the structure of the soft parts as well as of the shells. Such a scheme is introduced here, at first, tentatively, but I hope it finally will prove to be the most convenient.

Finally I should mention the glochidia of these forms. The latter are known in a number of North American species, where they always are of a primitive shape (see Plate XIX, fig. 1). They are also

known in European forms, where they incline toward the type of the subfamily *Anodontinae*. I have no doubt that this finally will be a very important systematic criterion, but unfortunately we do not know the glochidia of a single Asiatic species.

The following provisional division into genera in accordance with what has been hereinbefore said is here submitted:

- a*<sub>1</sub>. Beak-sculpture ranging from the concentric to the zig-zag type. Mantle connection between anal and supra-anal absent, deciduous, short, or of medium length. Inner lamina of inner gills free from abdominal sac.
- b*<sub>1</sub>. Mantle connection absent or short. Beak-sculpture concentric to zig-zag. Glochidia subovate, without hooks.
  - c*<sub>1</sub>. All four gills serving as marsupia. Mantle connection between anal and supra-anal present, short and deciduous.<sup>9</sup>
    - d*<sub>1</sub>. Ovisacs and placenta<sup>10</sup> subcylindrical, the latter rather persistent, generally red. Shell simple, without sculpture upon disk. Beak-sculpture simple, concentric..... **Fusconaja**.
    - d*<sub>2</sub>. Ovisacs and placenta leaf-shaped (compressed and lanceolate), the latter rather poorly developed, generally white. Shell with sculpture of various patterns. Beak-sculpture concentric, double-looped, or zig-zag.
      - e*<sub>1</sub>. Shell with oblique undulations upon the disk. Beak-sculpture concentric, nearly obliterated, or of zig-zag pattern and extending more or less upon the disk..... **Crenodonta**.
      - e*<sub>2</sub>. Shell-sculpture tuberculous or nodulose. Beak-sculpture concentric and disappearing upon the disk, or of the double-looped or zig-zag pattern, more or less extending upon the disk. **Quadrula**.
  - c*<sub>2</sub>. Marsupium formed by the outer gills only.
    - d*<sub>1</sub>. Mantle-connection above anal opening absent, no supra-anal formed. Shell tuberculous, beak-sculpture of zig-zag pattern, much broken up, extending somewhat upon the disk. Nacre deep purple..... **Rotundaria**.
    - d*<sub>2</sub>. Mantle connection between anal and supra-anal present, short, or deciduous. Beak-sculpture concentric, obliterated toward the disc.
      - e*<sub>1</sub>. Shell tuberculous. Soft parts of a peculiar orange color. Placenta pink (at least in one species)..... **Plethobasus**.

<sup>9</sup> Under this division apparently belong two species occurring in Georgia and Florida, *infucata* Conrad and *kleiniana* Lea, the soft parts of which have been partly described by Lea (Obs., X, 1863, pp. 404 and 407). In these species we observe the most beautifully developed zig-zag sculpture among North American forms. The soft parts are imperfectly known, but the marsupium is formed by all four gills. Probably they should form a genus by themselves.

<sup>10</sup> Called "egg plates" by Lillie (1895), and "conglutinates" by Lefevre and Curtis (1910).

- e<sub>2</sub>. Shell without sculpture. Soft parts more or less whitish, rarely slightly colored. Placentæ whitish, rarely slightly colored.
- f<sub>1</sub>. Shell elongate and oblique, with the beaks placed rather anteriorly, or rounded, squarish, or even elevated. Epidermis light, brownish, rarely dark brown, with or without rays. Nacre light colored. Beak-sculpture concentric, poorly developed. . . . . **Pleurobema.**
- f<sub>2</sub>. Shell more or less elongate, but not oblique, beaks not much anterior. Epidermis dark or light, generally without rays, or rays indistinct.
- g<sub>1</sub>. Shell with rather dark epidermis, sometimes faintly rayed. Nacre often dark (pink to purple). Beak-sculpture concentric, with an angle upon the posterior ridge, but not double-looped, often faint and rudimentary. . . . . **Elliptio.**
- g<sub>2</sub>. Shell with lighter epidermis (often with dark bands), rays practically absent. Nacre whitish. Beak-sculpture rather distinct, concentric, bars not angled behind, but regularly curved up. . . . . **Uniomorus.**
- b<sub>2</sub>. Mantle-connection between anal and supra-anal openings well developed, but generally shorter than the anal. Shell not sculptured upon the disk, elongated, but not oblique. Beak-sculpture sharply double-looped or of the zig-zag type. Glochidia subtriangular, with hooks. . . **Unio.**
- a<sub>2</sub>. Beak-sculpture of the radial pattern. Mantle connection between anal and supra-anal present, rather long. Inner lamina of inner gills connected with abdominal sac.
- b<sub>1</sub>. All four gills marsupial. Beak sculpture radial, well developed, more or less extending upon the disk. . . . . **Parreysia.**
- b<sub>2</sub>. Two outer gills only marsupial. Beak-sculpture concentric-radial, rudimentary. . . . . **Lamellidens.**

Genus *FUSCONAJA* Simpson. 1900.

Simpson, 1900b, p. 784 (as section).

I consider this the most primitive type of the *Unionidæ* known to me.

Shell simple, rounded, ovate, quadrate, or triangular, with more or less elevated beaks, well developed hinge-teeth, and rather deep beak-cavities. Outer surface without sculpture. Epidermis lighter or darker brown, with hair-like, dark rays, sometimes fused into spots when young. Beak-sculpture simple, concentric, slightly angled upon the posterior ridge, but not double-looped, not extending upon the disk, and often obliterated.

Soft parts of primitive structure. Supra-anal separated from the

anal, but mantle-connection between them very short, and deciduous, often absent. Inner lamina of inner gills free from abdominal sac. All four gills marsupial. There is hardly any difference in structure between the inner and outer gill. When gravid, the water-tubes (ovisacs) do not expand much, and their lumen remains nearly cylindrical. Placentæ also subcylindrical, generally red in color, rather persistent, and discharged whole. Glochidia rather small, subovate, without hooks.

Type: *F. trigona* (Lea), which (*cf.* Walker, 1910b, p. 24) should bear the name *undata* (Barnes).

#### ***Fusconaja undata* (Barnes).**

About a half dozen specimens of the form from Lake Erie have been examined, and in July, 1910, I found a few gravid specimens. Mr. H. E. Wheeler sent two males, and six females (one of the latter gravid) from the Ouachita River, Arkadelphia, Arkansas, collected March 21, 1911.

This form agrees in all essential points with *F. rubiginosa*. The ova, placenta, and sexual glands have the same red color. The soft parts are less inclined to orange, are paler, and often whitish and cream-colored. Simpson (in Baker, 1898, p. 76) gives a rather meager description. The glochidia are unknown, all specimens found by myself had only eggs.

The gravid female from Arkadelphia was just beginning to charge the gills. This early date (March 21) should be noted.

#### ***Fusconaja rubiginosa* (Lea).**

Numerous specimens, in all conditions, have been examined, all collected in the smaller creeks of the Ohio drainage in western Pennsylvania.

This species is typically tachytictic, but the breeding season is rather long, from the middle of May to the beginning of August. In the case of single individuals it is probably much shorter.

Descriptions of the soft parts have been given by Lea (Obs., X, 1863, p. 416) and Simpson (in Baker, 1898, p. 78).

Edges of the mantle drawn together by the gill-diaphragm, thus separating the anal and branchial openings. Anal opening closed above by a very short mantle-connection, thus forming a very large supra-anal; but this mantle-connection is very inconstant and de-

ciduous, often absent, sometimes torn. Branchial opening with papillæ on inner edge, anal with distinct, but small papillæ. Palpi subfalciform, pointed behind, their posterior margins connected for about one-third to one-half of their length.

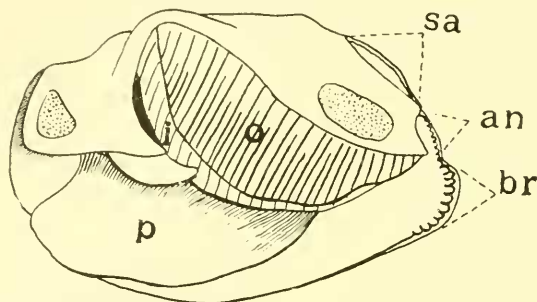


FIG. 4. *Fusconaja rubiginosa* (Lea). Male, from South Fork of Tenmile Creek, Waynesburg, Greene Co., Pa. (Carn. Mus., No. 61, 4,509.) Coll. May 6, 1910.

Gills short and rather wide, with curved lower margins (corresponding to the shape of the shell), the inner gill wider. Outer gill attached at its anterior end at the highest point of the attachment-line of the

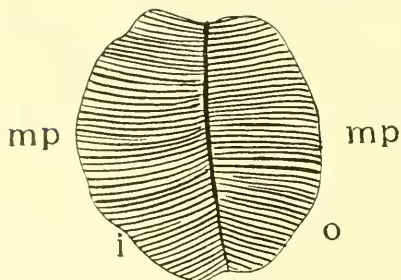


FIG. 4a. Left gills of a sterile female from same locality.

mantle, far above the palpi; inner gill with its anterior end slightly in front and below that of the outer gill, widely separated from the palpi. Outer lamina of outer gills entirely connected with the mantle. Inner lamina of the inner gill free from the abdominal sac, except at its anterior end. Behind the foot, the two inner laminae of the inner gills are connected up to their

posterior end. Thus a complete gill-diaphragm is formed, which reaches backward close to the posterior margin of the mantle.

Both gills possess well developed septa and water-tubes, running parallel to the gill-filaments. In the male, the septa are rather distant and the water-tubes are wide. The septa are merely lines of connection of the interlaminar tissue. In the female, all four gills are marsupial, the septa are better developed, thicker and longer (in the

transverse direction), more independent structures, with an epithelium thrown up into folds. They are much closer together, and form much narrower water-tubes, which, when gravid, become ovisacs. There is no noticeable difference in the width of these water-tubes in the inner and outer gill. When charged, the ovisacs do not expand much, and their lumen remains subcylindrical, so that the whole marsupium does not swell to any considerable degree, and its edge does not distend and remains sharp.

The ova are red in color, and are lodged in the ovisacs in the shape of well developed placentæ (sticking together by their membranes). The placentæ, conforming to the shape of the ovisacs, are subcylindrical, and are discharged whole through the anal opening.

The glochidia (see Ortmann, 1911*b*, pl. 89, fig. 2) are rather small, of suboval shape, without hooks. Length and height about equal, 0.15 mm.

The color of the soft parts is somewhat variable, but generally a yellowish-orange. The margin of the mantle, the distal part of the foot, and the adductor muscles, are deeper in color (intense orange-brown), while the gills are pale yellowish or brownish. The gills of the gravid female appear red when charged with the ova, and inside of the whitish abdominal sac the gonads are very often red. In certain specimens the color of the soft parts is altogether paler, the bright orange tints being missing, but this difference in color does not depend on sex.

### ***Fusconaja cerina* (Conrad).**

One male specimen at hand, received from L. S. Frierson. It is from Bayou Pierre, De Soto Parish, Louisiana.

Structure in all points like that of *F. rubiginosa*, and agreeing also in minor details, such as the papillæ of the anal and branchial openings, separation of anal and supra-anal, inner laminae of the inner gills, and palpi.

A female was not at hand. But Mr. Frierson writes to me concerning this species: "eggs in four gills," and "*cerina* has the body white in about half, but red in the other half of the specimens. Some have red eggs. But red eggs and red body are not correlated."

Thus it seems that this species stands very close to *F. rubiginosa*, a relationship, which has been assumed by others on the ground of the characters of the shell.

***Fusconaja lananensis* (Frierson).**

Frierson (1901, p. 76) describes the soft parts as: "salmon-colored, scarlet when cut" (probably sexual glands). "Eggs carried in all four gills, very red." This, together with the general shape of the shell, renders it almost certain that this species should be placed here.

***Fusconaja subrotunda* (Lea).**

I have investigated numerous individuals in all conditions collected by myself in the Ohio and Allegheny Rivers in western Pennsylvania, and some additional ones from the Ohio between Pittsburgh and Cincinnati.

The breeding season falls in June and July.

The soft parts have been described by Lea (Obs., X, 1863, p. 427).

This species agrees well with *F. rubiginosa*, but special mention should be made of the anal opening, which has fine crenulations, and shows the same variability as regards the short mantle-connection separating it from the supra-anal. The structure of the gills (see Ortmann, 1911b, pl. 86, figs. 1-3) is essentially the same as in *F. rubiginosa*.

The ova are generally red, but in rare instances they are pale pink or white. The placenta are also subcylindrical, and are discharged whole. The glochidia are similar to those of *F. rubiginosa*, but slightly higher than long.\* Length 0.13 mm.; height 0.15 mm.

In the color of the soft parts, two types may be distinguished. Normally there is much orange color present, which is most intense (deep orange-red) on the foot, the mantle margins, and the adductors, while the rest, chiefly the gills, are more brownish. When charged the gills are red. In the other type of color all parts are whitish or yellowish, or brownish-white, the latter color chiefly on those parts, which are orange in the other type. Yet there are intergrades between these two types, the orange color gradually passing into the brown. In western Pennsylvania, the orange type prevails. There is no relation of these colors to sex.

The color of the gonads deserves special mention in this species for comparison with the next. In all specimens examined it is either whitish or paler or deeper red, the latter of a distinct crimson hue, identical with the color of the eggs, but generally more intense. This crimson is found both in the male and in the female, so that it seems that also the sperm is thus colored.



**Fusconaja ebena** (Lea).

Of this species I have examined only very few typical representatives, found by myself in the Ohio River at Portsmouth, Scioto County, Ohio (Sept., 1910).

The soft parts of a gravid female have been figured by Lefevre and Curtis (1910, pl. 1, fig. 4). Although this figure is correct, the structure of the gills is not well represented, and the septa are not visible.

I was inclined to regard this form as only a variety of *F. subrotunda*, but Dr. Sterki differs from me in this, and he calls my attention to the fact that the color of the gonads in *F. ebena* is not *crimson*, as in *subrotunda*, but distinctly *purple*. I have been able to verify this. Although I had before me not more than half a dozen *F. ebena*, and although I found the gonads white in some, the others had them more or less (lighter or darker) purple, differing distinctly in hue from specimens of *subrotunda*, which I had at hand simultaneously. This matter, however, should be further investigated.

In other respects *F. ebena* agrees with *F. subrotunda*, and also has the two types of color of the soft parts, whitish and orange. I have never seen gravid females, but Lefevre and Curtis (1910, p. 97, fig. 1) have figured the glochidium, which is identical with that of *F. subrotunda*, and has practically the same dimensions (length 0.14; height 0.15).

**Fusconaja kirtlandiana** (Lea).

Numerous specimens, chiefly from the Beaver drainage in western Pennsylvania have been investigated, among them only one gravid female with glochidia (found in the beginning of August).

This agrees in every detail with *F. subrotunda*. The only difference is that the orange type of color of the soft parts is rather infrequent, while the whitish prevails. The only gravid female was of the orange type, and had crimson gills. Glochidia identical. Length 0.13; height 0.15 mm. (see Ortmann, 1911b, pl. 89, fig. 1).

I am very much inclined to consider this as being only a variety of *F. subrotunda*.

Genus CRENODONTA Schlueter. 1836.

Simpson, 1900b, p. 766 (as section).

Shell rounded, ovate, subquadrate, or trapezoidal, with more or less elevated beaks, well developed hinge-teeth, and rather deep beak-

cavities. Outer surface with a peculiar sculpture: heavy, oblique folds run across the disk chiefly in its posterior half (it may be that these folds are continuations of the posterior angle of the bars of the beak sculpture). Epidermis lighter or darker, brown to blackish, without distinct rays. Beak-sculpture either simply concentric, slightly angled upon the posterior ridge, and disappearing toward the disk, or continued upon the disk in a zig-zag pattern, much broken up, and irregular. The soft parts are primitive in structure. Supra-anal separated from the anal, but the mantle-connection between them very short and often absent. Inner lamina of inner gills free.<sup>11</sup> All four gills are marsupial, but there is a slight differentiation in the structure of the inner and outer gills, the water-tubes of the inner gill being slightly wider than those of the outer gill. When gravid, the ovisacs expand a little more, so that their lumen becomes transversely enlarged, giving to the placenta a compressed, leaf-like shape. Placenta whitish, not very solid, and not persistent, and the glochidia are discharged in loose masses. Glochidia small, subovate, without hooks.

Type *C. plicata* (Say).<sup>12</sup>

*Crenodonta* approaches the following genus more than the preceding, in fact, it is very closely allied to *Quadrula*. The chief differential character is the sculpture of the shell.

#### ***Crenodonta plicata* (Say).**

Of this species, which is commonly called *Quadrula hippopæa* (Lea). I have investigated numerous specimens from the shores of Lake Erie in Pennsylvania and Ohio. Gravid females were found in July, 1910, but only eggs were present in them, and no glochidia.

Since there was at hand much more complete material of the following form, of which this is undoubtedly only a local race, I prefer to only give particulars of the anatomy of *C. undulata*, here only stating that *C. plicata* is absolutely identical with it in every respect.

#### ***Crenodonta undulata* (Barnes).**

A large number of specimens from the Ohio drainage in western Pennsylvania are at hand. This species is tachytictic, and the breed-

<sup>11</sup> I have never seen it connected, although it is said to be so sometimes.

<sup>12</sup> This species has been misunderstood hitherto. The type locality of *plicata* is Lake Erie, and thus the only known *Crenodonta* from Lake Erie should bear this name, but this is the form called *hippopæa* by Lea. The *plicata* of authors (incl. Simpson) should be *Cr. peruviana* (Lamarck).

ing season lasts from the middle of May to the middle of July. The discharge of the glochidia has been observed on July 8, 1909.

The soft parts have been described by Lea (Obs., X, 1863, p. 417), but incorrectly in several particulars. They also have been described by Simpson (in Baker, 1898, p. 82).

Margin of the mantle drawn together by the gill-diaphragm, thus separating the anal and branchial openings. Anal and supra-anal separated by a very short mantle-connection, which is sometimes absent (torn?). Branchial opening with strong papillæ, anal also with papillæ, which, however, are much finer, and sometimes appear only as crenulations. Palpi of the usual shape, their posterior margins connected only at base or up to one-third of the length.

Gills broad, the inner the wider, their anterior ends as usual. Diaphragm normal, and inner lamina of the inner gills free from the abdominal sac, except at the anterior end.

Gills with well-developed septa and water-tubes, as usual. In the female, marsupial structure is observed in all four gills, the septa being better developed, with folded epithelium, closer together, and the water-tubes being narrower. Yet in the outer gill the water-tubes are somewhat narrower than in the inner gill, which is chiefly noticeable at the base of the gills. In the gravid female, the gills swell moderately, so that the ovisacs assume a lanceolate, leaf-like shape, while the edges of the gills remain sharp and do not distend. Eggs whitish, filling the ovisacs in rather poorly connected masses, although a placenta-like cohesion is seen. But later on this placenta-structure is lost, and the glochidia are discharged in rather loose, irregular masses.

Glochidia of suboval shape, without hooks. Length 0.21; height 0.22 mm. (see Lea, Obs., VI, 1858, pl. 5, fig. 22, but not quite correct in shape; Ortmann, 1911*b*, pl. 89, fig. 3).

Color of soft parts whitish, foot, margin of mantle and gills pale brownish or yellowish. No trace of any brilliant colors (red or orange).

#### ***Crenodonta perplicata* (Conrad).**

One male, and two females, from Bayou Pierre, De Soto Parish, Louisiana, collected Aug. 6, 1910, have been received from L. S. Frier-son. One of the females proved to be gravid, and in the act of discharging glochidia. Three males, three females, and two young ones from Ouachita River, Arkadelphia, Arkansas, have been sent by H. E. Wheeler.

This form is very likely the southern representative of the foregoing. It agrees with it in every respect. In one of the specimens from Louisiana and three from Arkansas the supra-anal was separated from the anal, in the others this separation was absent. The inner edge of the anal is finely crenulated. The posterior margins of the palpi are connected for about one-third of their length, and the inner lamina of the inner gills is free from the abdominal sac.

The gill-structure of the females is identical with that of *C. undulata*. The gravid female had only a few glochidia in the outer gills, while the inner ones were yet partly charged, and both suprabranchial canals, as well as the cloacal chamber, were filled with masses of loose glochidia, partly sticking together, but not in the shape of placenta.

Glochidia like those of *C. undulata*. Length 0.20; height 0.21 mm.

#### **Crenodonta heros (Say).**

According to the description and figure given by Lea (as *multiplicatus*, Obs., VII, 1860, p. 222, pl. 30, fig. 105), this species without doubt belongs here.

#### **Crenodonta trapezoides (Lea).**

I have received, from L. S. Frierson, one male and two females from Bayou Pierre, De Soto Parish, Louisiana (collected Aug. 6, 1910),

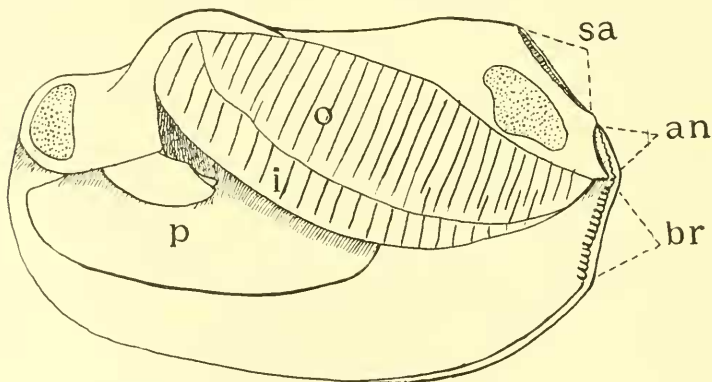


FIG. 5. *Crenodonta trapezoides* (Lea). Male, from Bayou Pierre, De Soto Parish, La. (Carn. Mus., No. 61, 4,586.)

from A. A. Hinkley two females from Pearl River, Jackson, Hinds Co., Mississippi (collected Nov. 5, 1910), and from H. E. Wheeler a male

and a female from Ouachita River, Arkadelphia, Clark Co., Arkansas. None of the females was gravid.

The description of the soft parts given by Lea (Obs., X, 1863, p. 436) is incomplete.

The anal opening is separated from the supra-anal by a moderately long connection of the margins of the mantle, which varies slightly, and is a little longer than the anal, but always much shorter than the supra-anal. In two cases this connection was absent. Branchial with well developed papillæ, anal with minute papillæ. Inner lamina of inner gills free, except at the anterior end. Posterior margins of palpi connected for about one-half of their length.

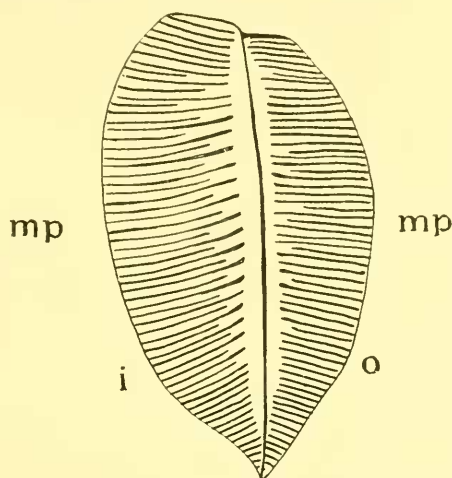


FIG. 5a. Left gills of a sterile female of *C. trapezoides*, from Pearl River, Jackson, Hinds Co., Miss. (Carn. Mus., No. 61, 4,924.)

Septa of the gills of the male rather distant from each other, and water-tubes wide. In the female the septa are much more crowded, and the water-tubes are narrow, chiefly so in the outer gill. In the inner gill of the female, near the base, the septa are a little more distant, but toward the edge they become more crowded by intercalation of additional ones, so that in the marginal half of this gill the water-tubes are almost as narrow as those of the outer gill. Altogether the marsupial character of the crowded septa is not so distinctly pronounced in the inner gill, although all four gills are built to receive eggs and to serve as marsupia, a fact, which is evidenced by the struc-

ture of the septa and the epithelium, which is folded and wrinkled as usual in marsupial gills.

Soft parts whitish. Frierson writes to me that in this species "eggs are in two gills sometimes, mostly in all four." Of those sent to me (five females), the structure of the gills was alike, in every case all four gills had the marsupial structure as described above.

In this species I see the nearest approach to a tendency to restrict the marsupial function to the outer gills, in so far as the water-tubes are slightly wider in the inner gills. But still the latter partake in the formation of the marsupium, and are distinctly marsupial at least in their marginal half.

This species stands rather isolated also with regard to the characters of the shell, but the features of *Crenodonta* are clearly seen, and I think that the most closely allied form is *C. heros*.

Genus QUADRULA Rafinesque. 1820.

Simpson, 1900b, p. 765 (restricted).

Shell rounded, quadrate, or subrhomboidal, sometimes elongated, with rather high beaks, well developed hinge-teeth, and deep beak-cavities. Outer surface more or less sculptured, with tubercles, pustules, or ridges, but without the characteristic oblique folds of *Crenodonta*. Epidermis lighter or darker, generally with rays, and often with beautiful color-patterns caused by the breaking up of the rays. Beak-sculpture concentric, double-looped, or zig-zag, poorly developed, or extending upon part of the disk.

Soft parts primitive in structure. Supra-anal separated from the anal by a short mantle-connection, the latter sometimes absent. Inner lamina of inner gills free. All four gills marsupial (see Plate XVIII, fig. 1), but the water-tubes of the inner gills sometimes a little wider than those of the outer gills, although this difference is occasionally hardly noticeable. When gravid, the ovisacs expand moderately, giving a compressed, leaf-like shape to the placenta. Placenta (where known) whitish, not very solid, and not persistent. Glochidia, in the few cases known, small, or medium, subovate, without hooks.

Type *Q. metanevra* (Rafinesque).

The species belonging to this genus may easily be separated into three groups:

1. *Pustulosa*-group.

Shell more or less rounded and swollen over the disk, with pustules

(rarely smooth), which are irregularly scattered, and have no connection with the beak-sculpture. Beak-sculpture poorly developed, simply concentric.

*Q. pustulosa, sphaerica, refulgens, mortoni.*

2. *Lachrymosa*-group.

Shell subquadrate or subtrapezoidal, sometimes somewhat elongate. Generally profusely sculptured upon the disk with tubercles, pustules, and ridges of a more definite arrangement. This sculpture is continuous with the beak-sculpture, which is quite distinct, and of the double-looped type. Shell with a rather distinct, but narrow, posterior ridge and in front of this flattened, or with a broad and shallow depression. Epidermis rayed, rays not broken, but irregular, and with the tendency to spread over the epidermis.

*Q. lachrymosa, aspera, tuberculata.*

3. *Metanevra*-group.

Shell subquadrate, or subtrapezoidal, sometimes quite elongated. Surface generally sculptured with tubercles and pustules of a more or less distinct arrangement, the sculpture continuous with the beak-sculpture, which is of the double-looped or zig-zag type. Shell with a distinct, broad, and high posterior ridge, depressed in front of this, but without distinct and broad radial furrow. Epidermis rayed, rays broken up into characteristic triangular spots.

*Q. metanevra, sparsa, cylindrica.*

### ***Quadrula pustulosa* (Lea).**

I have investigated about half a dozen specimens from the Ohio drainage in western Pennsylvania, West Virginia, and Ohio, and (var. *schoolcraftensis* Lea) from Lake Erie in Ohio. Further I had ten specimens, males and females, from Ouachita River, Arkadelphia, Clark Co., Arkansas (H. E. Wheeler). Both males and females were seen, but none of the latter gravid.

The soft parts have been described by Simpson (in Baker, 1898, p. 87).

Anatomy similar to that of the genera *Fusconaja* and *Crenodonta*, chiefly the latter. Anal and supra-anal separated by a short mantle-connection. I never found the latter absent. Branchial opening with papillae, anal crenulated. Palpi of the usual shape, their posterior margins connected for about one-third of their length.

Gills short and broad (according to shape of shell), the inner gill



the wider. Anterior attachment of gills as usual. Diaphragm normal. Inner lamina of inner gills free from abdominal sac except at anterior end.

Gills with well-developed septa, which are rather distant in the male. In the female, all four gills are marsupial, the septa being close together, and the water-tubes narrow. In the inner gill the septa are slightly less crowded near the base, but they have the characteristic marsupial structure (see Ortmann, 1911a, pl. 7, fig. 1).

The glochidia are figured by Lefevre and Curtis (1910, p. 97, fig. F). Length 0.23; height 0.32, which is unusually large for this group of genera.

The color of the soft parts is grayish, or yellowish white.

### ***Quadrula sphærica* (Lea).**

Three sterile females from Pearl River, Jackson, Hinds Co., Mississippi, are at hand, collected on Nov. 5, 1910, by A. A. Hinkley.

Structure essentially as in *Q. pustulosa*. Anal opening with fine crenulations, almost smooth. In all three specimens all four gills possess the marsupial structure, and the water-tubes of the inner gills are also not quite so narrow as those of the outer gills, chiefly near the base.

By its shell this species is very closely allied to the foregoing, and the soft parts are practically identical. I hardly think they are specifically distinct, and among the specimens of *pustulosa* from Ouachita River, mentioned above, there are intergrades between the two forms.

### ***Quadrula refulgens* (Lea).**

One male, collected together with *Q. sphærica*, is before me.

Since there is only a male, the characteristic *Quadrula*-structure cannot be made out. But I have no doubt that this is a *Quadrula* on account of its close affinity to *Q. sphærica*. In fact all the details, both of the shell and the soft parts, are identical with the latter, except that the shell is more compressed (lenticular) in *Q. refulgens*. My specimen is more rounded in outline than the original figure of Lea, and thus more nearly approaches *Q. sphærica* in this character. I should not be astonished, if *refulgens* should turn out to be a mere "form" of *sphærica*.

***Quadrula mortoni* (Conrad).**

Three males and two females, one of the latter gravid, from Bayou Pierre, De Soto Parish, Louisiana, collected by L. S. Frierson, Aug. 6, 1910.

Agreeing in every detail with *pustulosa* and *spharica*, to which it is allied. The inner edge of the anal opening is almost smooth.

In the gravid female, eggs and glochidia were present, the latter of the usual shape, of medium size, subovate, without hooks. The glochidia are quite young and their shape is not very distinctly seen. They were of whitish color, and distributed in an irregular way in certain ovisacs both of the outer and inner gills, many ovisacs being empty. No exact measurements of the glochidia can be given.

The date for the breeding season should be noted.

***Quadrula lachrymosa* (Lea).**

One male and four females from the Wakarusa River, Lawrence, Douglas Co., Kansas, received from R. L. Moodie, and one female collected by myself in the Ohio River, at St. Marys, Pleasants Co., West Virginia. No gravid females have been seen.

Soft parts described by Simpson (*cf.* Baker, 1898, p. 84).

Similar to the preceding species. Inner edge of the anal opening irregularly and indistinctly crenulated, almost smooth. Posterior margins of palpi connected for over one-half, almost two-thirds, of their length.

All four gills are marsupial, septa of the inner ones slightly less crowded than those of the outer ones (see Plate XVIII, fig. 1).

Soft parts whitish.

***Quadrula aspera* (Lea).**

Three males, one female (all small, or of medium size) from Bayou Pierre, De Soto Parish, Louisiana, collected by L. S. Frierson, and one very large female from Pearl River, Jackson, Hinds Co., Mississippi, collected by A. A. Hinkley.

An incomplete description is given by Lea (*Obs.*, X, 1863, p. 437).

Agreeing in every respect with *Q. lachrymosa*, to which it is closely allied. Even the minor details (anal opening, palpi, etc.) are absolutely identical. No gravid females have been seen.

*Quadrula tuberculata* (Barnes).

Fifteen specimens have been investigated, collected by myself in the Ohio drainage in western Pennsylvania; nine more have been received from H. E. Wheeler from the Tennessee drainage in northern Alabama, and the Ouachita River in Arkansas. Females are among them, but not in the gravid condition.

Simpson has created for this species the genus *Tritogonia*, which he removed far from *Quadrula*. The shape of the shell is indeed somewhat strange at the first glance, but it is possible, without much difficulty, to correlate shape and sculpture with that of such species as *lachrymosa*, *aspera*, and chiefly with certain southern forms, which probably also belong here (*forshei* Lea, *speciosa* Lea, *apiculata* Say).

In the structure of the soft parts, this species is essentially a *Quadrula*. The anal opening is separated from the supra-anal by a rather short mantle-connection; the latter was found absent in one case only (out of twenty-four). Branchial with well developed papillæ, anal with fine, but distinct crenulations, which sometimes resemble fine papillæ. Inner lamina of inner gills free from abdominal sac, except at its anterior end. Posterior margins of palpi connected for one-half, or even more, of their length.

Gills rather long, but also rather wide; their anterior attachment as usual. Septa well developed, rather distant from each other in the male. In the female they are more crowded in all four gills, and the water-tubes are narrow, but there is a slight difference between the inner and outer gill, the water-tubes of the former being slightly wider near the base of the gills. In the marginal portion there is hardly any difference in the water-tubes of the two gills (see Ortmann, 1911*b*, pl. 86, fig. 4). In all four gills the septa are distinctly marsupial in structure: they are heavy, and have a folded epithelium.

No gravid females have been seen by the writer, and the glochidia are still unknown.

The color of the soft parts is grayish or yellowish (or brownish) white.

Simpson (1900*b*, p. 608) says of his genus *Tritogonia*: "in the female there is a thickened flap of the mantle which fills the circular posterior expansion of the shell, and which has a small flap inside." I have never seen anything answering to this phrase in my specimens. The chief expansion of the shell is at the anal opening, and the margin of this opening corresponds to it, and thus the anal is larger in the female,

than in the male. The "inside flap" can only be the inner edge of the mantle, which is present, however, in the male also. The true position of this species was first indicated by Sterki (1907, p. 48).

***Quadrula metanevra* (Rafinesque).**

Thirteen specimens of either sex, one a gravid female, were examined in the laboratory, all from the Allegheny and Ohio Rivers in western Pennsylvania; additional specimens were examined in the

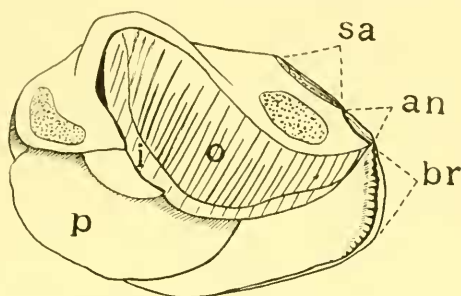


FIG. 6. *Quadrula metanevra* (Rafinesque). Male, from Allegheny River, Kelly, Armstrong Co., Pa. (Carn. Mus., No. 61, 4,549.) Coll. May 20, 1910.

field, in the Ohio River in West Virginia and Ohio, and two (male and female) were received from the Ouachita River in Arkansas (H. E. Wheeler).

The gravid female was found on June 22, 1909, and had only eggs.

Margins of the mantle connected so as to separate anal and supra-anal openings; this connection is short, but in no case was found to be absent. Supra-anal very large. Branchial with well developed papillae, anal practically smooth, or only with mere traces of irregular crenulations. Palpi with the posterior margins connected for about one-fourth to one-third of their length.

Gills short and wide, their anterior attachment as usual. Dia-

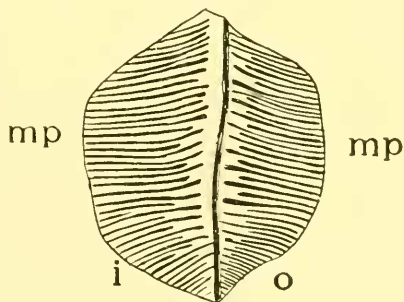


FIG. 6a. Left gills of a sterile female, from same locality.

phragm normal. Inner lamina of inner gills free from abdominal sac, except at anterior end.

Septa and water-tubes well developed. In the female all four gills are marsupial, and possess the typical structure. In the basal portion of the inner the water-tubes are somewhat wider, but there is hardly any difference in their width in the marginal part of the two gills, since the water-tubes of the inner gills become narrower by intercalation of additional ones. In the gravid female the gills swell moderately, but their edges remain sharp. The eggs form only poorly developed placenta in the ovisacs, and the shape of the latter is compressed and lanceolate (leaf-like).

The eggs are whitish. I have not seen glochidia, but according to Lefevre and Curtis (1910, p. 97, fig. E) they are normal in shape and size. Length 0.18; height 0.19 mm.

Color of soft parts whitish. As usual, the edge of the mantle, chiefly along the posterior part, is more or less blackish or brownish. Gills paler or darker grayish or brownish white. Foot brownish white. The posterior part of the abdominal sac is often suffused with black.

#### ***Quadrula sparsa* (Lea).**

One male and one sterile female, from the Cumberland River in Cumberland and Pulaski Counties, Kentucky, at hand, received from B. Walker.

Identical in every detail with *Q. metanevra*, to which it is also allied by the shell. The agreement extends so far, that minor details are also identical, as the smooth edge of the anal, the shape of the palpi, and the black pigment of the posterior part of the abdominal sac.

In the male supra-anal and anal were not separated, but this region was somewhat injured, so that the mantle-connection may have been torn.

Charged marsupia and glochidia unknown.

#### ***Quadrula cylindrica* (Say).**

Nine specimens (males and females) from the Ohio drainage of western Pennsylvania have been examined in the laboratory, and several more in the field, taken from the Ohio River in western Pennsylvania and Ohio. Two males were received from H. E. Wheeler, from the Ouachita in Arkansas.

Although the shape of the shell is very unique in this species, it clearly belongs to the *metanevra*-group, as has been recognized already by Simpson, and the soft parts bear out this affinity, since they are identical in all essential characters. Of course, according to the shape of the shell, the gills are very long and narrow. The mantle connection between anal and supra-anal was always found present. The inner edge of the anal is practically smooth. The posterior margins of the palpi are united for about one-half of their length.

All four gills have a marsupial structure in the female, and the inner gill has the water-tubes a little wider in the basal part than the outer gill. No gravid specimens have been found.

The color of the soft parts of this species is very remarkable. The general ground color is yellowish orange, with black markings. The abdominal sac is whitish, with blackish gray markings, chiefly posteriorly. The foot is grayish at the extremity, shading into black, the black ending in a sharp horizontal line, which is followed by grayish orange. The palpi are yellowish, with a gray edge, the gills are grayish brown, the mantle transparent gray, shading to grayish yellow on the margin, with a blackish brown edge, which becomes deep black and very wide posteriorly at the siphons. The adductors are pale yellowish to orange. The color varies in different specimens in so far that in some the ground-color is paler yellow, while in others it is of a more intense yellow, inclining to orange.

Breeding season and glochidia unknown.

#### Genus ROTUNDARIA Rafinesque. 1820.

Simpson, 1900b, p. 794 (as subgenus).

Shell rounded or quadrate, with elevated beaks, very deep beak-cavities, and well developed hinge-teeth. Outer surface sculptured with tubercles and nodules. Epidermis brown, without rays. Beak-sculpture consisting of numerous rather close bars, the first few concentric, those following developing a strong angular loop on the posterior ridge, and an anterior loop, which soon breaks up into an irregular zig-zag pattern of more or less isolated tubercles. This sculpture extends somewhat upon the disk and mingles with the first tubercles of the disk. Nacre more or less violet, which may be a specific character.

Soft parts primitive in structure. The anal is never closed above,

and no supra-anal is present. Inner lamina of inner gills free. Of the gills, only the outer ones are marsupial in the female, and the water-tubes in them are much closer than in the non-marsupial gills. Glochidia unknown.

Type *R. tuberculata* (Rafinesque).

This genus is more primitive than any of the foregoing because of the absence of a supra-anal opening. In the structure of the marsupium it is a little more advanced, and is related to the following genera. In the characters of the shell it is rather peculiar, but reminds somewhat of certain types of *Quadrula*. We can do justice to these conflicting characteristics only by recognizing this as a valid genus.

***Rotundaria tuberculata* (Rafinesque).**

Three males and three females from the Ohio drainage in western Pennsylvania, and one female from the Ohio River at St. Marys, Pleasants Co., West Virginia, all collected by myself, have been investigated.

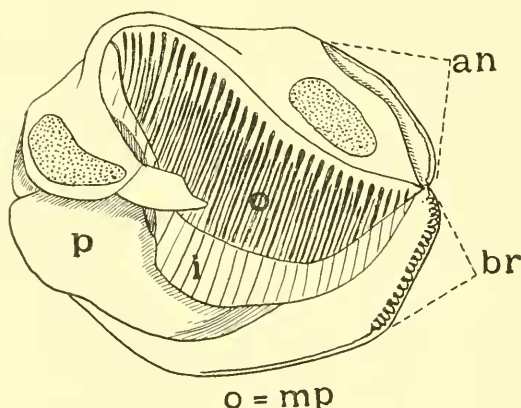


FIG. 7. *Rotundaria tuberculata* (Rafinesque). Sterile female, from Allegheny River, Kelly, Armstrong Co., Pa. (Carn. Mus., No. 61, 4,562.) Coll. July 25, 1910.

The soft parts have been described by Simpson (in Baker, 1898, p. 86), but very poorly.

Although there are only a few specimens at my disposal, the characters given for the genus are uniformly found in all of them. The most marked character is the absence of a supra-anal. Since Simpson



also mentions this character, I think we may take it as settled that this form does not possess a supra-anal. As regards the marsupium, I can only say that in all four females at hand only the outer gills show the marsupial structure.

In conclusion there is nothing remarkable in the structure of the soft parts. The branchial opening is unusually large, and has papillæ on the inner edge, while the large anal has a practically smooth inner edge. The palpi are normal, and their posterior margins are united for one-third to one-half of their length. The gills, conforming to the shape of the shell, are rather short and wide, and their anterior ends are normal, the diaphragm is complete, and the inner lamina of the inner gills is free from the abdominal sac, except at the anterior end. The gills have the usual structure, and the female marsupial structure is found only in the outer gills, where the septa are much more crowded, and the water-tubes much narrower, than in the non-marsupial gills.

A gravid female has never been found, and consequently the glochidia remain unknown.

The color of the soft parts is grayish or brownish white, with exception of the margin of the mantle, which is brownish, and becomes deep black in the region of the branchial and anal openings.

Genus *PLETHOBASUS* Simpson. (1900.)

Simpson, 1900*b*, p. 764 (as section).

Shell rounded, oval, or slightly elongate, with moderately elevated beaks, and moderately deep beak-cavities, and well developed hinge-teeth. Outer surface sculptured with nodules or tubercles, which often are transversely elongated. Epidermis yellowish to brown, without distinct rays. Beak-sculpture rudimentary, consisting (as far as known) of a few concentric ridges, which do not extend upon the disk. Nacre whitish or pinkish.

Soft parts primitive in structure. Anal separated from the supra-anal by a short mantle-connection. Inner lamina of inner gills free. Only the outer gills are marsupial in the female, in other respects the gills have the usual structure. When gravid, the outer gills swell moderately, and their edges do not distend. Placentæ lanceolate (leaf-like) and compressed; they are rather persistent, and are discharged whole. Glochidia small, semioval, without hooks.

Type *P. asopus* (Green).

Possibly the color of the soft parts and of the eggs (placentæ) is also characteristic. (See below.)

This genus greatly resembles in shell-structure the genus *Quadrula*, chiefly the *pustulosa*-group and the genus *Rotundaria*. But in the marsupium it is more advanced than the former, and in the color of the soft parts and the eggs it suggests affinity with *Fusconaja*. It surely is a connecting link between the more primitive *Unioninae* and those of the type of the genus *Pleurobema*. Simpson has recognized the peculiar character of *P. æsopus*, and I think his section *Plethobasus* is entitled to generic rank.

***Plethobasus æsopus* (Green).**

Some fifty specimens have been examined, chiefly from the Allegheny River in Armstrong Co., Pennsylvania. Among them were gravid females, and the latter were found exclusively in the month of July. The species is typically tachytictic.

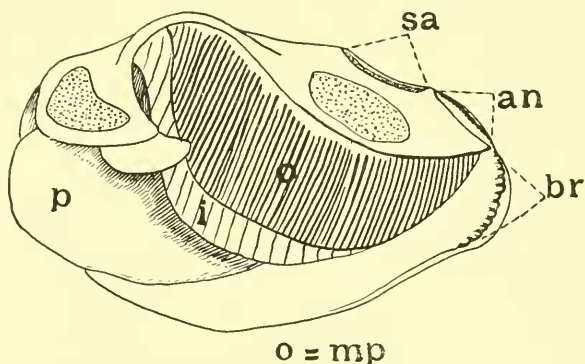


FIG. 8. *Plethobasus æsopus* (Green). Sterile female (just discharged), from Allegheny River, Kelly, Armstrong Co., Pa. (Carn. Mus., No. 61, 4,598.) Coll. July 25, 1910.

Anal and supra-anal separated by a very short mantle-connection, which was found missing in a small number of cases. Branchial opening with strong papillæ, anal with very fine papillæ. Palpi of usual shape, their posterior margins connected for about one-third of their length.

Gills long and broad, the inner the wider. Anterior attachment as usual. Diaphragm normal. Inner lamina of inner gills free. Septa

and water-tubes well developed, septa rather distant in the male. In the female, only the outer gill is marsupial, with crowded septa, while in the inner gill the septa are like those of the male.

When gravid, the water-tubes (ovisacs) of the outer gill swell moderately, and assume a lanceolate shape, and consequently the placenta have this shape. The edge of this gill does not distend. The eggs and placenta are pink or red, and the placenta preserve their shape, and are discharged whole. This discharge has been actually observed in two cases (July 25, 1910).

Glochidia of the usual shape, rather small, semioval, without hooks.<sup>13</sup>

Color of soft parts very characteristic. All specimens seen had a peculiar, pale orange ground-color. The foot, margins of the mantle, and adductors were darker, often deep orange. The abdominal sac is whitish, the palpi and gills pale grayish brown, the gills with more or less of the orange hue. The color may be more or less intense, but some shade of orange always prevails. When gravid, the red color of the placenta contained in the gills blends with the orange of the latter, producing a very peculiar lilac tint.

#### ***Plethobasus cooperianus* (Lea).**

Only two specimens with soft parts have been observed, the one from the Ohio River in Beaver Co., Pennsylvania, the other from the Ohio at Parkersburg, Wood Co., West Virginia. Both proved to be females.

The anatomy of this species is practically identical with that of *P. asopus* agreeing in all particulars, chiefly also in the peculiar color of the soft parts. This color is so characteristic that it alone suggested to me the relationship of *cooperianus* and *asopus*, which was confirmed by the subsequent anatomical investigation. No gravid females have been observed, and nothing is known about the color of the placenta and the shape of the glochidia.

Genus **PLEUROBEMA** Rafinesque. 1820.

Simpson, 1900b, p. 745 (amended).

Shell rounded, subquadrate, oval, or somewhat elongate, but then oblique, with the beaks placed anteriorly. Beaks generally somewhat

<sup>13</sup> The glochidia were observed only in one case, in one of the discharging females, and apparently were discharged prematurely (a phenomenon observed by others). They were young and incompletely formed (soft), but their shape could be made out. The size was about 0.18 mm., but it was impossible to make exact measurements.

prominent, with moderately deep beak-cavities; hinge-teeth well developed. Outer surface without sculpture. Epidermis generally lighter or darker brownish, sometimes yellowish, with more or less distinct rays, which may be arranged in blotches, or may be fine lines, or entirely absent. Beak-sculpture obscure, consisting of a few concentric ridges, not extending upon the disk. Nacre generally whitish, or red.

Soft parts practically identical with those of *Plethobasus*, except in color, which is generally paler, sometimes yellowish, even with a suggestion of pale orange (in *P. clava*), but in most cases without this. The eggs are, where known, white, and the placenta are distinct, and seem to be persistent. Glochidia small, suboval, without hooks.

Type *P. clava* (Lamarck).<sup>14</sup>

It is an unhappy coincidence, that the type species does not represent the normal condition of the genus, but a rather extreme form of it. In general, we may say that *Pleurobema* resembles *Quadrula* in the soft parts, and *Fusconaja* in the shape of the shell, with the exception that it has reached the advanced stage of having only the outer gills marsupial. It differs from the following genera (*Elliptio* and *Unio-merus*) only by the characters of the shell, chief among which is the general outline, which is of the short, rounded, quadrate, or oblique type, while *Elliptio* and *Unio-merus* have the elongate and straight type of shell. Simpson (1900b, p. 760, footnote 2) had difficulty in defining this genus, and there are indeed species which are to a degree intermediate between *Pleurobema* and *Elliptio*. *P. clava* is a peculiar type. Since I have not had any opportunity to investigate these doubtful forms, I have made the present arrangement of the genera to suit the material at hand, but I shall not be astonished if further studies will necessitate changes.

#### ***Pleurobema riddelli* (Lea).**

One young male, and one larger female (sterile) are before me, from Pearl River, Jackson, Hinds Co., Mississippi, collected by A. A. Hinkley.

I was a little uncertain about the identification of this species, but since Mr. Walker, to whom I sent these specimens, also thinks that they are *riddelli*, I believe the identification is right.

<sup>14</sup> The species of *Pleurobema* described by Rafinesque are unrecognizable, but L. Agassiz (1852) has made this the type.

Structure of the soft parts like those of the following species, which see. Color of soft parts also of similar type. Mantle-connection separating anal and supra-anal very short. Anal with fine crenulations, branchial with papillæ. Posterior margin of palpi connected for about one-half of their length.

Gills of the usual structure, in the female only the outer gills are marsupial (see Plate XVIII, fig. 2).

In the soft parts there are no characters which assign this species to a definite genus, except that they indicate, that it is not *Fusconaia* and not *Quadrula*. It has been placed by Simpson in the latter genus. In the shape of the shell it most resembles the *coccineum-obliquum*-group of *Pleurobema*, from which it is distinguished by the rather distinct posterior ridge. I think, *P. riddelli* comes in here, but stands rather isolated by itself. The dark color of the epidermis is also unusual in this genus.

#### ***Pleurobema coccineum* (Conrad).**

Numerous specimens have been examined from the smaller creeks of the Ohio and Lake Erie drainage in western Pennsylvania, among them some fifty gravid females. The species is tachytictic, and the breeding season lasts from the end of May to the end of July.

The soft parts have been described by Simpson (in Baker, 1898, p. 79), but the account given of the marsupium is wrong.

Margin of the mantle, branchial, anal, and supra-anal openings of the usual conformation, as also the gills and palpi. Branchial with papillæ, anal with distinct, almost papillæ-like crenulations. The mantle-connection between the anal and supra-anal was found absent in some cases. Posterior margins of palpi connected for one-half, or even more, of their length.

Only the outer gills are marsupial.<sup>15</sup> When gravid, the outer gills swell only moderately, the edges remaining sharp. The ovisacs are compressed and lanceolate and the placenta, which are distinctly developed, have the same leaf-like shape; they are always white, and are permanent, being discharged whole. This discharge has been observed several times. Glochidia rather small, subovate, without

<sup>15</sup> Lefevre and Curtis (1910, p. 83) suggest that the fact that I found only the outer gills charged may be due to a partial discharge of the marsupia in consequence of beginning suffocation. This supposition is untenable. I observed many specimens in the field. Moreover, even in females, which have the marsupium not charged, it is easily seen that only the outer gills have marsupial structure.

hooks (see Ortmann, 1911b, pl. 89, fig. 4). Length and height about the same: 0.15 mm.

Color of soft parts grayish or yellowish white. Among the numerous specimens investigated not one has been found which showed any traces of orange color.

#### **Pleurobema obliquum** (Lamarck).

A large number of specimens from the Ohio and Allegheny in Pennsylvania, and the Ohio in West Virginia and Ohio have been investigated. Gravid females have been found only a few times in June.

Structure of soft parts absolutely identical with that of *P. coccineum*, but glochidia have not been observed.

I do not think that this form is specifically distinct from *P. coccineum*. It is the form of the large rivers, which is represented in the headwaters and smaller streams by *P. coccineum*. In the Allegheny River in Armstrong Co., Pennsylvania, these two forms are connected by all kinds of intergrades.

#### **Pleurobema pyramidatum** (Lea).

Not more than a dozen specimens of typical *pyramidatum* have been seen, found always associated with the foregoing form. Females were among them, but none gravid. I also received one male and three females of this form from Arkadelphia, Arkansas, collected by H. E. Wheeler.

This is merely an extreme variety of *P. obliquum*, connected with it by frequent transitional forms, and consequently the anatomy is absolutely identical.

#### **Pleurobema clava** (Lamarck).

About twenty-five specimens, among them gravid females, have come under observation. They are all from the Ohio drainage in western Pennsylvania. This species is gravid in June and July.

The soft parts have been described by Lea (Obs., X, 1863, p. 441), but only those of the male.

Anatomy like that of the other species of *Pleurobema*. It should be mentioned that the mantle-connection between the anal and supra-anal is rather short, and was always found present. The anal is rather distinctly, but finely, papillose. Posterior margins of palpi connected for only a short distance.

The outer gills alone are marsupial, and the placenta are rather distinct. Glochidia (see Ortmann, 1911*b*, pl. 89, fig. 5) of small size, subovate, without hooks. Their length and height is about the same, 0.16 mm.

Color of soft parts whitish, with foot and gills grayish, and the margin of the mantle black posteriorly. In other specimens the foot

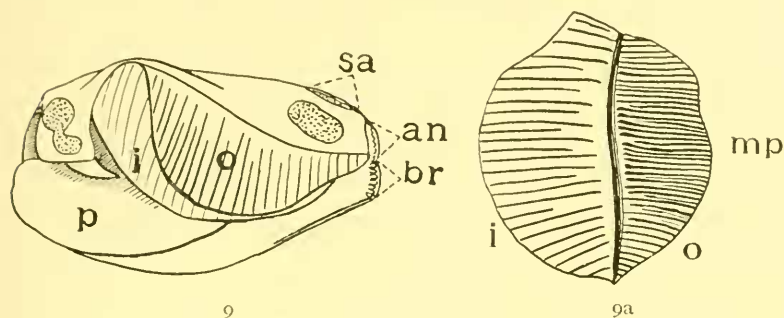


FIG. 9. *Pleurobema clava* (Lamarck). Male, from Sandy Creek, Sandylake, Mercer Co., Pa. (Carn. Mus., No. 61, 4,589.) Coll. June 27, 1910.

FIG. 9a. Left gills of sterile female, from Shenango River, Pulaski, Lawrence Co., Pa. (Carn. Mus., No. 61, 4,591.) Coll. Oct. 4, 1910.

is pale orange, as are also the margins of the mantle and adductors. The gills are grayish brown. There are all intergrades between these extremes. The placenta are white, cream-color, or pale orange.

### ***Pleurobema decisum* (Lea).**

According to the similarity of the shell, and the notes on the anatomy furnished by Lea (Obs., X, 1863, p. 405), this species belongs here.

Genus *ELLIPTIO* Rafinesque. 1819.

Simpson, 1900*b*, p. 700 (as section).

Shell more or less elongated, with straight longitudinal axis, not oblique. Beaks not very near the anterior end, not very prominent, with shallow beak-cavities; hinge-teeth well developed. Outer surface without sculpture.<sup>16</sup> Epidermis generally rather dark, brown to black, without rays, or with indistinct rays, chiefly so when young. Rays straight, simple, and fine. Beak-sculpture tending to become

<sup>16</sup> If *U. spinosus* belongs here, the diagnosis should be modified in this particular.



obsolete; when present, consisting of few fine concentric ridges, to which may be added, toward the disk, a small number of slightly heavier bars, with a posterior angle upon the posterior ridge of the shell; these bars run about parallel to the growth lines. Sometimes the bars are slightly sinuate in front of the posterior angle, but they never are distinctly of the double-looped type. Nacre from white through all shades of pink and red to deep purple and violet, with the dark shades prevailing.

Soft parts practically identical with those of *Plethobasus* and *Pleurobema*, with only the outer gills marsupial. Mantle-connection between anal and supra-anal short, or somewhat longer. Inner lamina of inner gills free. Color of the soft parts whitish, often greatly suffused (chiefly the gills and mantle) with black. Eggs, where known, whitish, placenta rather distinct. Glochidia small, subovate, without hooks (see Plate XIX, fig. 1).

It may be mentioned as an additional character, that in all these forms the anal has rather distinct papillæ.

Type: *E. crassidens* (Lamarck.)<sup>17</sup>

We may regard *Elliptio* as a special branch of *Pleurobema*, distinguished from the latter only by the characters of the shell. It probably is not descended directly from a *Quadrula*- or *Fusconaia*-like type with four marsupial gills, but it has gone through the intermediate *Pleurobema*-stage first.

The species of *Elliptio* easily fall into several groups.

In *E. crassidens* and *beadleianus*, the typical shape of the shell is not so distinctly developed: it is not greatly elongated, and approaches yet somewhat the subquadrate or subtrapezoidal type of certain *Fusconaia*- and *Pleurobema*-species. The beak sculpture in these forms is rather obscure.

Next to this stands the group of *E. complanatus* (including *productus* and *jayensis*), where the typical characters of the genus are fully developed.

A third type is furnished by *E. gibbosus*, and a fourth by *E. popei*.

### ***Elliptio crassidens* (Lamarck).**

Numerous specimens both males and females have been examined, all from the Ohio and Allegheny Rivers in western Pennsylvania.

<sup>17</sup> *Unio (Elliptio) nigra* Rafinesque, 1820, is Rafinesque's type (first species), and this is undoubtedly a synonym of *U. crassidens* Lamarck, 1819. The large, heavy shell of the Ohio with red nacre cannot be anything else.

There were only three gravid females among them, which were found on June 22, 1909.

Anatomy normal: margin of the mantle, siphons, gill-structure, and marsupium typically Unionine. In a few cases the rather short

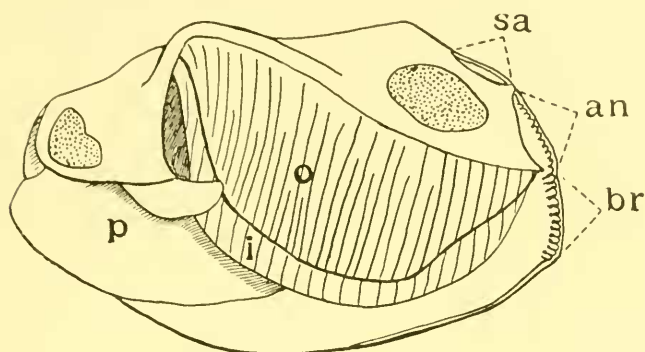


FIG. 10. *Elliptio crassidens* (Lamarck). Male, from Allegheny River, Kelly, Armstrong Co., Pa. (Carn. Mus., No. 61, 3,777.) Coll. July 3, 1908.

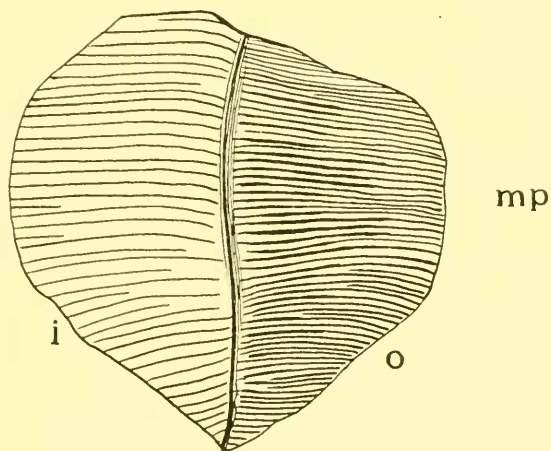


FIG. 10a. Left gills of a sterile female, from same locality. (Carn. Mus., No. 61, 3,055.) Coll. Sept. 5, 1907.

mantle-connection between the anal and supra-anal was found to be absent. Anal with small, but quite distinct, papillae. Palpi with the posterior margins connected for a short distance.

Marsupium formed by the outer gills; when gravid moderately swollen, with rather well-developed, leaf-like placentæ. Glochidia (see Ortmann, 1911*b*, pl. 89, fig. 6) small, suboval, without hooks. Length 0.13; height 0.15 mm. The color of the abdominal sac is whitish, the foot pale gray or brownish gray, the mantle pale liver-brown, whitish toward the margins, edge brown, black posteriorly. Gills gray or dirty brown. Adductors whitish, palpi grayish.

***Elliptio beadleianus* (Lea).**

Two males and two females, from Pearl River, Jackson, Hinds Co., Mississippi, have been received from A. A. Hinkley.

This species, which has been placed by Simpson (1900*b*, p. 786) in the genus *Quadrula*, is not a *Quadrula*, because only the outer gills have marsupial structure. In other respects its anatomy is indistinguishable from that of other forms belonging in the genera of the type of *Pleurobema*, etc. The shape of the gravid marsupium, of the placentæ, and of the glochidia is unknown.

The supra-anal opening is well separated from the anal, but the separating mantle-connection is short. The inner edge of the anal has fine, but distinct, papillæ, that of the branchial has larger papillæ. The posterior margins of the palpi are connected for one-third or one-half of their length (this is the most prominent difference from the allied forms). The inner lamina of the inner gills is free, as usual.

Although the structure of the gills unquestionably removes this species from *Quadrula* and *Fusconaja*, it is hard to assign it a place in the other genera. We must rely entirely upon the shell, and this is rather an indifferent criterion. However, I think the shape of the shell is more like that of *crassidens* than that of any other form. It is somewhat more elongate than the *Fusconaja-Pleurobema*-type, straight, with the beaks not much anterior, with a dark epidermis, and with a tendency to develop red nacre, characters which are all found in *E. crassidens*. The posterior ridge is also present in both species.

I consider *E. beadleianus* a peculiar type, standing nearest to *E. crassidens*. Probably other species go with it, as for instance *chickasawhensis* Lea and *askewi* Marsh (of the latter two, Frierson writes to me that they are "next to inseparable"). All these differ from *crassidens* in being smaller, possessing more regularly swollen lateral faces of the disk, lacking corrugations on the posterior slope, and having a lighter nacre. Also the whole shell and the hinge are less massive in structure. Their beak-sculpture is unknown.

Color of soft parts of *E. beadleianus* whitish; foot grayish; gills and palpi grayish-brown, as is also the mantle, except the margin, which is whitish, with the edge blackish posteriorly.

***Elliptio* (?) *spinosus* (Lea).**

The anatomy has been described by Lea (Obs., X, 1863, p. 413). It is similar to that of *E. crassidens*, but Lea mentions some peculiarities in the ovisacs, which I do not understand. The shell is of the *crassidens*-type, but its spines are unique and would possibly justify the erection of a separate genus: *Canthyrina* Swainson, 1840.

***Elliptio complanatus* (Dillwyn).**

Numerous specimens of this species, males, sterile and gravid females, have been investigated from the Delaware, Susquehanna, and Potomac drainages of eastern Pennsylvania and Maryland. The species is tachytictic, and the breeding season begins at the end of April, and lasts to the middle of June, possibly a little longer.

The soft parts have been described by Lea (Obs., X, 1863, p. 412).

In the shell, this is a typical *Elliptio*, with the typical shape of this genus, and its typical beak-sculpture. In the soft parts, we find the edges of the mantle forming the usual openings. Anal and supra-anal are separated by a moderate mantle-connection, shorter than the anal, which has never been found missing. The branchial has large papillæ, while the anal has much finer ones. Posterior margins of palpi connected for a short distance.

Gills corresponding to the shape of the shell, rather long and moderately wide, the inner rather wider. Diaphragm of the usual shape, inner lamina of inner gill free, except at anterior end. Septa and water-tubes well developed, the latter wide in the male. In the female only the outer gills are marsupial, and their septa are much crowded. When gravid, this gill swells only moderately, the edge remaining sharp, and the ovisacs assume a leaf-like shape, as also do the placentæ (figured by Lillie, 1895, pl. 1, fig. 1), which are not very solid when glochidia are present. The latter are always white, rather small, subovate, without hooks. They are longer than high. Length 0.20, height 0.19 mm. (see Plate XIX, fig. 1).

Color of soft parts of the grayish white type, foot darker, also gills, the latter often suffused with black posteriorly.

***Elliptio jayensis* (Lea).**

Five males and twelve females (all sterile) from Lake Monroe, Sanford, Orange Co., Florida, collected by O. T. Cruikshank, in April, 1907.

The soft parts are of the usual structure, and agree in every particular with those of *E. complanatus*. Anal and supra-anal separated by a mantle-connection, which is slightly longer than in the more primitive forms, but still considerably shorter than the anal. Anal with rather well developed papillæ, which are almost as large as the papillæ of the branchial opening. Posterior margins of palpi connected at base only. Inner lamina of inner gill free, except at anterior end. Only the outer gills are marsupial.

The beak-sculpture of this species is not quite of the normal *Elliptio*-type, in that in the case of the later bars a sinuation is seen in front of the posterior angle. This sinuation is variable, and never assumes the shape of a distinct, reëntering angle, and thus the beak-sculpture cannot be called double-looped.

There are over one hundred shells (without the soft parts) at hand, many of which might as well be called *E. buckleyi* (Lea). All these shells undoubtedly are the same species, and were collected together.

The old ones most resemble *buckleyi* (see: Simpson, 1892, pl. 58, figs. 6 and 7, and pl. 59, fig. 1), while those of medium size and the young ones are *jayensis* (Simpson, *ibid.*, pl. 61, fig. 4). It is remarkable that there are no young *buckleyi* in the lot, while there are dozens of *jayensis*. I am very much inclined to regard *buckleyi* as being only the older adult form of *jayensis*.

***Elliptio productus* (Conrad).**

Nine specimens have been investigated, males and sterile females, from the Potomac drainage in southern Pennsylvania and Maryland.

The soft parts agree in all essential respects with those of *E. complanatus*. Conforming to the shape of the shell, the gills are extremely long and narrow. Branchial, anal, and supra-anal as in *complanatus*; anal and supra-anal separation slightly longer than usual; anal with the same distinct papillæ. Structure of palpi and gills the same. No gravid females have been found.

Color of soft parts like that of *complanatus*.

Beak sculpture practically identical, and there is no doubt that this species is an offshoot of the *complanatus*-stock.

***Elliptio gibbosus* (Barnes).**

Numerous specimens from the Ohio and Lake Erie drainage in western Pennsylvania have been seen, and two males and two females from Arkansas. Gravid females were found in the months of May, June, and July, and in one case as late as August 13. This is a typical tachytictic form.

The soft parts have been discussed by Lea (Obs., X, 1863, p. 417) and Simpson (in Baker, 1898, p. 70).

The beak-sculpture in this species is also similar to that of *E. complanatus*, but it is slightly heavier, though less distinct; that is to say: the ridges are thicker, but less well defined.

Soft parts essentially identical with the other species described in this genus. It, however, should be mentioned that in a very few cases the mantle-connection between the anal and the supra-anal was found missing. The anal has distinct papillæ.

When gravid the marsupium swells moderately, but the edge remains sharp. The ovisacs are leaf-shaped, and the placenta are moderately well-developed, but when the glochidia are formed, they seem to be less distinct. Color of eggs and glochidia always white. Glochidia (see Lea, Obs., XIII, 1874, pl. 21, fig. 10; and Ortmann, 1911b, pl. 89, fig. 7) rather small, suboval in shape, without hooks. Length 0.20, height 0.22 mm.

Color of soft parts grayish white. Foot, gills, and mantle gray, edge of the latter black posteriorly. Marsupium cream-white.

***Elliptio popei* (Lea).**

Two gravid females, from Valles River, Mexico, collected by A. A. Hinkley in December and January, 1906-1907,<sup>18</sup> were received from L. S. Frierson.

The beak-sculpture is somewhat different from that which is typical of this genus. In the two specimens before me, it is poorly developed, although the beaks are well preserved. It consists of two to three fine concentric ridges, which are somewhat interrupted in the middle, giving a faint appearance of double loops. But it is not by any means double-looped, since no reëntering angles are present.

The soft parts are typical. The anal and supra-anal are separated by a mantle-connection, which is shorter than the anal. Anal with well-developed papillæ; papillæ of branchial larger than those of anal.

<sup>18</sup> See Hinkley, 1907, pp. 68 and 79.

Posterior margins of palpi connected for a short distance. Inner lamina of inner gills free, except anteriorly.

Both of my specimens are gravid, but have only eggs. Marsupium formed by the outer gills, only moderately swollen, with sharp edge. Placentæ moderately well developed.

Hinkley collected these specimens in December and January. Here we would have a so-called "summer breeder," which breeds in mid-winter. But we know now, that not the season of the year, but the shortness of the breeding season is important, and according to all analogies, *E. popei* should be a form with short breeding season.

#### Genus UNIOMERUS Conrad. (1853.)

Conrad, 1853, p. 268.—Simpson, 1900*b*, p. 739 (as section).

Shell moderately elongated, with straight longitudinal axis, not oblique, and beaks not very near the anterior end. Beaks not very prominent, beak-cavities shallow, hinge-teeth well developed. Outer surface without sculpture. Epidermis light yellowish to brown, often with dark concentric bands, without rays. Beak-sculpture rather distinct, concentric, bars rather numerous, not angled behind, but curved up toward the posterior side of the beaks, and not parallel to the growth lines. Nacre whitish or grayish, not inclining to purple or red. Soft parts practically identical with those of *Elliptio*. Gravid females are unknown, but in sterile females only the outer gills are marsupial in structure. The anal has, in the type species, only crenulations, and the mantle-connection between anal and supra-anal is rather long.

Type *U. tetralasmus* (Say).<sup>19</sup>

This genus stands very close to *Elliptio*, and, like this, may be regarded as descended from *Pleurobema*.

#### *Uniomerus tetralasmus* (Say).

One male and two females (sterile) from Bayou Pierre, De Soto Parish, Louisiana, have been received from L. S. Frierson.

The soft parts do not offer anything remarkable, when compared with those of *Pleurobema* and *Elliptio*. The supra-anal is separated from the anal by a rather long mantle-connection, the latter, however, is

<sup>19</sup> The first species given by Conrad is *declivis*, which, according to Simpson, together with six of the other so-called species named, are synonyms, or varieties, of *tetralasmus*.



shorter than the supra-anal, but distinctly longer than the anal. Inner edge of anal with fine crenulations, that of branchial with papillæ. Inner lamina of inner gills free, except anteriorly. Posterior margins of palpi connected for about one-fourth of their length. Marsupium formed by the outer gills, and of the usual structure. Color of soft parts whitish.

Genus *UNIO* Retzius. (1788.)


Simpson, 1900b, p. 679 (restricted).

Shell ovate, or more or less elongated, with straight longitudinal axis, not oblique, and beaks not very close to the anterior end. Beaks not very prominent, with shallow beak-cavities. Hinge-teeth well-developed. Outer surface without sculpture. Epidermis light or dark, with, or without, rays. Beak-sculpture distinctly of the double-looped type, or even zig-zag, with a distinct reëntering angle of the bars in front of the posterior angle. Often the sculpture is rudimentary, and consists of tubercles indicating the lower angles of the original loops.

Soft parts much like those of *Pleurobema*, *Elliptio*, and *Uniomorus*. Mantle-connection between anal and supra-anal moderately long (generally almost as long as the anal). Inner lamina of inner gills free, except at anterior end. Marsupium formed by the outer gills, with the usual structure (see Plate XVIII, figs. 4, 5). Gravid females have not been seen by the writer, but the glochidia are described by European authors as being moderately large, subtriangular, with a hook on the ventral point of each valve.

Type *U. pictorum* (Linnaeus).

This genus chiefly differs from the foregoing genera in the shape of the glochidia and in the beak-sculpture. Although the marsupium is similar to the North American genera *Pleurobema*, *Elliptio*, and *Uniomorus*, I do not think that this indicates close relationship, but that it is due to parallelism of development. The genus *Unio* of the Old World has started from certain *Unioninæ* (with four gills serving as marsupium) in an independent line of descent. We do not yet know the forms which probably were ancestral to *Unio*. The shape of the glochidium indicates that somewhere near *Unio* was the starting point for the development of the subfamily *Anodontinæ*.



**Unio pictorum** (Linnæus) 1758.

See also Ortmann, 1911c, p. 21.

A large number of specimens, both males and females, are at hand, from various parts of Germany and Hungary, received from W. Israël.

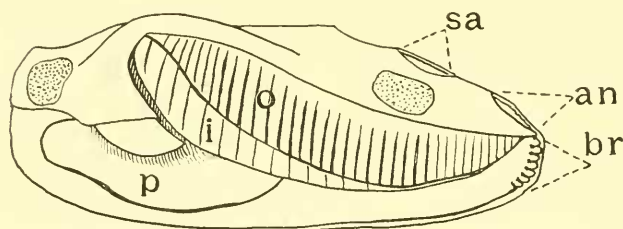


FIG. 11. *Unio pictorum* (Linnæus). Male, from Saale River, Rudolstadt, Germany. (Carn. Mus., No. 61, 4,934.)

Branchial opening separated from the anal by a complete diaphragm formed only by the gills. Anal opening closed above by the union of the margins of the mantle, forming a supra-anal; this mantle-connection is rather long, slightly longer than the anal, and about as long as the supra-anal. Inner edge of branchial with distinct papillæ, that of the anal almost smooth, or with very minute crenulations. In front of the branchial the inner edge of the mantle is practically smooth. Palpi subfalciform, their posterior margins united for about one-third of their length, or slightly more.

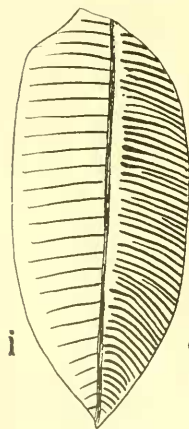


FIG. 11a. Left gills of a sterile female, same locality.

Gills (corresponding to the shape of the shell) rather long and narrow, the inner the wider, chiefly so anteriorly. Anterior end of the gills as usual, that of the inner widely distant from the palpi. Outer lamina of outer gill entirely connected with the mantle, inner lamina of inner gill free from abdominal sac, with exception of its anterior end.

Both gills with well-developed water-tubes and continuous septa. The septa of the inner gill of the male (see Plate XVIII, fig. 3) and

female (see Plate XVIII, fig. 4) are rather distant from each other; in the outer gill of the male, they are slightly more crowded. But in the female the septa of the outer gill are very close, forming narrow water-tubes (see Plate XVIII, fig. 4). The epithelial lining of the latter water-tubes is marsupial in character. Thus the marsupium is formed by the outer gills alone practically throughout their whole extent; for small sections at the anterior and posterior ends of the gill, which have wider water-tubes, pass gradually into the marsupial part, and may be disregarded.

Gravid females are not at hand. According to previous observations of other authors (Harms, 1908, p. 696, fig. 1, and 1909, pp. 322 and 334; Haas, 1910a, p. 107), the glochidia are subtriangular, with hooks. Size 0.29 mm.

#### **Unio tumidus** Retzius.

The soft parts of four males and six females from Germany and Hungary are at hand, received from W. Israël.

Structure essentially identical with that of *U. pictorum*. No gravid females have been observed. The glochidia have been figured by Schierholz (1889, pl. 4, fig. 63).

#### **Unio crassus** Retzius.<sup>20</sup>

Many specimens have been studied, received from W. Israël from the drainage of the river Elster in Thuringia, Germany.

In this species also the soft parts are identical with those of *U. pictorum*. The non-marsupial part at the anterior and posterior ends of the outer gills of the female is sometimes a little larger, but there are specimens exactly like *U. pictorum* in this respect. Glochidia have not been observed, and have not been described so far as I know.

#### **Unio crassus musivus** (Spengler).<sup>21</sup>

One male, and four females from Germany and Hungary have been sent to me by W. Israël.

Absolutely identical in structure with *U. crassus*. A female from the river Begas, Hungary, had a few ovisacs near the middle of the

<sup>20</sup> For nomenclature, see Thiele, 1909, p. 35.

<sup>21</sup> This form is not *batarus* Maton and Rackett, 1907 (see Haas, 1910a, p. 108, and 1910c, p. 167), but is surely *batarus* Lamarck, 1819, which name, consequently, cannot be used. As Haas (1910d, p. 62) has shown, the oldest name is *musivus*, Spengler, 1793.

right outer gill filled with eggs. There were also eggs in the supra-branchial canal. No glochidia were seen. The water-tubes had no lateral water-tubes developed.

**Unio crassus consentaneus** (Rossmæssler).

A male from the drainage of the Danube in Bavaria, and three males and four females from the Danube in Hungary, were sent to me by W. Israël.

Agrees in all particulars with the foregoing forms. (A cross-section of the gills of the female is seen on Plate XVIII, fig. 5.)

Genus **PARREYSIA** Conrad. (1853.)<sup>22</sup>

Simpson, 1900*b*, p. 840.—Ortmann, 1910*b*, p. 139.

Shell subovate or subquadrate, with rather high beaks, moderately deep beak-cavities, and well developed hinge-teeth. Epidermis bright, sometimes rayed. Beak-sculpture of the radial type: two sets of radial ridges run from in front and from behind the beaks in the direction of the lower margin. The two sets of radial ridges meet in the middle of the shell in an acute angle, and sometimes extend well upon the disk.

Soft parts partly primitive, partly more advanced. Supra-anal separated from the anal by a well developed mantle-connection, which is rather long. Inner lamina of inner gills entirely connected with the abdominal sac. All four gills are marsupial in the female, with well developed septa and water-tubes, which latter are somewhat narrower in the outer gill than in the inner. In the male, the septa are distinctly more distant than in the female. During pregnancy, the gills swell but little, and the edges remain sharp, and the ovisacs remain simple.

Placentæ subcylindrical, only slightly compressed, and not very solid. Glochidia not observed.

This genus, in the structure of the soft parts, corresponds to *Fusconaia*, *Crenodonta*, and *Quadrula*, to which it is apparently related, but represents another type of development of beak-sculpture, which may be derived from the simple *Fusconaia*-sculpture. Some minor features of the soft parts indicate that it has advanced a little along its

<sup>22</sup> Determined only by the type-species, *multidentata* Philippi = *corrugata* Mueller (see Conrad, 1853, p. 267). The investigated species, *wynegungaensis* Lea is closely allied to the type.

own line, which is also indicated by the full development of the beak-sculpture. It may be possible, that species forming connecting links with *Fusconaja* still exist in eastern Asia. The investigation of additional, related types is much to be desired, and we should try especially to become acquainted with the glochidia.

***Parreysia wynegungaënsis* (Lea).**

A number of specimens from Bombay, India, have been sent to me by L. S. Frierson. As to the description, I refer to my previous publications (Ortmann, 1910b, p. 139, and 1911a, p. 106, pl. 6, fig. 4, pl. 7, fig. 3).

Genus *LAMELLIDENS* Simpson. (1900.)

Simpson, 1900b, p. 854.—Ortmann, 1911a, p. 106.

This genus bears about the same relation to *Parreysia*, as does *Unio* and *Elliptio* to *Fusconaja* and *Quadrula*. A complete diagnosis cannot be given at the present time, but the differences known to exist in the only species examined are the following: Outer gills alone marsupial, the shell more elongated, with the beak-sculpture rudimentary.

As to the latter character, I may mention that I have seen, in a specimen of *L. consobrinus*, as well as in specimens of *L. marginalis* (Lamarck) in the Carnegie Museum, that the sculpture starts with a few (one or two) fine, concentric bars, and, following these, other bars are added, of which, however, only the lateral (anterior and posterior) parts are developed, which assume a direction radiating from the anterior and posterior side of the beak. These radiating ridges are very short, and I think they give us a clue as to the derivation of the radiating sculpture from the concentric. I think the *Lamellidens*-sculpture represents a phylogenetically older stage of beak-sculpture, while in other characters the form investigated is somewhat more advanced.

***Lamellidens consobrinus* (Lea).**

One single sterile female from India has been investigated; I received it from L. S. Frierson. For the anatomy see my previous publication (Ortmann, 1911a, p. 106, pl. 7, fig. 4).

Subfamily *ANODONTINÆ*.

To this subfamily belongs, first of all, the European genus *Anodonta*, which is the typical genus, and which also occurs in North America, and probably likewise in Asia. In North America there are a number of additional genera, in some respects even more primitive than *Anodonta*, of which I have examined the following: *Alasmidonta*, *Strophitus*, *Symphynota*, *Arcidens*, *Anodontoides*, *Lastena*. They are all adopted from Simpson's Synopsis, and I do not see any reason for changing these generic divisions.

In the soft parts, they all very closely resemble each other. The fundamental idea, the physiological meaning of the anatomical peculiarities of this group, which governs its structure, is the following: these forms are *bradytic*, and the breeding season becomes a long one, and the glochidia, after having fully developed, are not discharged, but kept in the marsupium over winter.<sup>23</sup> This makes necessary a special apparatus for supplying the glochidia with the necessary oxygen during this period. The problem is solved by the development of a special apparatus to secure the circulation of water within the gills, which, in the diagnosis (p. 224), has been called that of the "lateral water-tubes." This apparatus exists only during the breeding season, but it has been found in all species the gravid females of which have been investigated. In sterile females traces of it are also generally discernible, since the lateral parts of the water-tubes often show indications of its presence in the conformation of their epithelium (see Plate XVIII, fig. 6). This is the most essential character of the subfamily.

Other characters are furnished by the development of thickened tissue along the edge of the marsupium, which permits the distending of this gill during pregnancy, and this character is also generally easily seen in sterile females. Further, the mantle-connection separating the anal and supra-anal is generally well, often very well, developed; the inner gill has the inner lamina free or connected with the abdominal sac. These latter two characters are of secondary value, but they help somewhat in the distinction of genera. The marsupium is always formed by the outer gills, the glochidia are rather large, subtriangular, and possess hooks. There are no generic distinctions observable in these characters, although the shape and size of

<sup>23</sup> Very few *Anodontinæ* are known from countries without a winter, but such are present. It would be very interesting to study their behavior in this respect.

the glochidia varies somewhat in the different species (see Plate XIX, figs. 2, 3, 4). In only one genus, *Strophitus*, the anodontine-structure of the marsupium has undergone a marked change, and has made a step in advance. Here each ovisac, which remains simple in other genera, is subdivided into a number of secondary compartments running in a direction transverse to the gill. There are also further peculiarities in the marsupium of this genus, which concern the mutual cohesion of the eggs and glochidia.<sup>24</sup>

*Strophitus* is the only genus, which must be separated from the rest on solely anatomical grounds. In the case of all other genera the only criteria are the differences of the shells sometimes supplemented by minor characters of the soft parts.

The shell, in this subfamily, is quite variable in shape, but in most forms it is not very thick, or it is even quite thin. The hinge is extremely variable, showing all stages from a complete development to complete reduction. If present, the hinge-teeth are peculiar: the pseudocardinals are supplemented, in the left valve by an additional (generally a third) tooth, which is formed by a projection of the *interdentum*, and extends *below* the corresponding part of the right valve. Sometimes this supplementary tooth is rudimentary, and it may be well separated from the posterior pseudocardinal, or may be fused with it.

A very important feature of the shell seems to me the beak-sculpture, which indicates two, possibly three, lines of development within this sub-family.

We would thus obtain the following scheme of classification:

- a<sub>1</sub>. Beak-sculpture double-looped, with a more or less sharp sinuation or re-entering angle. Mantle connection between anal and supra-anal moderate or very long. No tendency to unite the inner lamina of inner gills with abdominal sac.
- b<sub>1</sub>. Hinge-teeth more or less developed, at least pseudocardinals present. Shell not very thin.
  - c<sub>1</sub>. Beak-sculpture not tubercular, and no sculpture upon the disk, but sometimes upon the posterior slope. . . . . **Symphynota.**
  - c<sub>2</sub>. Beak-sculpture tubercular, and strong tubercles and other sculpture upon the disk. . . . . **Arcidens.**
- b<sub>2</sub>. Hinge-teeth completely absent. Shell smooth and thin. . . . . **Anodonta.**
- a<sub>2</sub>. Beak-sculpture concentric, fine. Hinge-teeth practically absent. Mantle-

<sup>24</sup> It is possible that the structural differences of *Strophitus* are connected with the fact recently discovered by Lefevre and Curtis (1911) that the glochidia of this genus do *not* pass through a parasitic stage on fishes.



- connection between anal and supra-anal moderately long. No tendency to unite the inner lamina of inner gills with abdominal sac. . . . **Anodontoides.**
- a*<sub>3</sub>. Beak-sculpture concentric, heavy. Mantle-connection between anal and supra-anal moderate. Certain forms with tendency to connect the inner lamina of inner gills with abdominal sac.
- b*<sub>1</sub>. Hinge-teeth more or less developed, at least the pseudocardinals present. Marsupium with simple ovisacs. Shell subrhomboidal. . . . **Alasmidonta.**
- b*<sub>2</sub>. Hinge-teeth rudimentary. Marsupium of gravid female unknown. Shell elongated. . . . . **Lastena.**
- b*<sub>3</sub>. Hinge-teeth rudimentary. Marsupium with ovisacs subdivided into transverse compartments. Shell subovate. . . . . **Strophitus.**

The most primitive types are undoubtedly *Symphynota* and *Alasmidonta*, and among them species with fully developed hinge-teeth are found. The most extreme modification of the soft parts is seen in *Strophitus*, while the most extreme specialization in the shell is represented by *Anodonta* (most successful adaptation to the life in quiet water with muddy bottom). *Arcidens* is peculiar in its shell sculpture. *Anodontoides* is a connecting form between *a*<sub>1</sub> and *a*<sub>3</sub>, but with the whole shell-structure more inclining toward *a*<sub>1</sub>. *Lastena* is yet rather doubtful in its position.

It must be pointed out that comparatively few forms have been investigated, and that further knowledge will possibly furnish the means for a better understanding of the phylogeny of this subfamily. There surely should be *Anodontinae* in Asia (aside from *Anodonta* proper), which possibly might be more primitive than any of those investigated hitherto. For the present, the most ancient types are known from North America, but I do not think that the subfamily originated in this continent. The shape of the glochidia indicates, that it started probably from a form near the European genus *Unio*, and this makes it more likely that the ancestral form lived in the Old World.

#### Genus SYMPHYNOTA Lea. (1829.)

(Simpson, 1900b, p. 662.)

Shell ovate or elliptic, compressed, with smooth disk, but sometimes with ribs upon the posterior slope. Beak-sculpture distinct, consisting of a few concentric bars, followed by others, which are distinctly sinuated,<sup>25</sup> or double-looped. Hinge with teeth, the pseudocardinals always present, the laterals present, imperfect, or absent.

Soft parts of typical structure: outer gills alone marsupial, when

<sup>25</sup> See description of beak sculpture of *S. costata*.

charged their edges distending, lateral (secondary) water-tubes present, ovisacs not subdivided. Placentæ very poorly developed, and only indicated when eggs are present. Inner lamina of inner gills free from abdominal sac.

Type *S. compressa* Lea. Very close to this stands *S. viridis* (Conrad). These two species are normally hermaphrodites, while the other two (*S. complanata* (Barnes) and *S. costata* (Rafinesque)) are gonochorists.

This genus is the most primitive among the *Anodontinae* with double-looped beak-sculpture. Simpson divides it into subgenera, which are well characterized, although there is not much need of a division of the genus on account of the small number of species.

### ***Symphynota compressa* Lea.**

Numerous specimens from northwestern Pennsylvania and other parts have been investigated.

This is a typical bradyctictic form, and the breeding season is normal, beginning in August, and ending in May (and June in Lake Erie).

The soft parts have been described by Lea (Obs., X, 1863, p. 423, as *pressus*), and Simpson (in Baker, 1898, p. 59).

Anal and supra-anal separated by a well-developed mantle-connection, which, however, is shorter than the anal. Inner edge of anal distinctly crenulated, that of the branchial with papillæ; farther in front the edge is practically smooth, only in the beginning fine crenulations are seen. Palpi subfalciform, their posterior margins united for about one-half of their length.

Gills broad, the inner the broader. Anterior end of inner gill about half way between the palpi and the anterior end of the outer gill. Gill-diaphragm normal. Inner lamina of inner gill free, except at anterior end.

Gills with well-developed septa and water-tubes. This species being normally hermaphroditic (see Ortmann, 1911*b*, p. 309), the gills have always (with extremely rare exceptions) the female structure, that is to say, in the inner gill the septa are rather distant, and the water-tubes are wide, and the outer gill is marsupial. When sterile, the septa are crowded, with marsupial epithelium, and the water-tubes are narrow. When gravid this gill swells considerably, and at the edge the tissue distends, so as to render the edge rounded off or truncated. Within this gill, each water-tube develops the characteristic

lateral, or secondary, water-tubes, while the middle portion forms the ovisac, which is also closed at the base of the gill. The eggs fill the ovisacs in densely crowded masses, and in certain places a placenta-like cohesion may be observed. But when the glochidia are mature, they are perfectly free, and no indications of placenta are seen. Glochidia subtriangular, almost semicircular, longer than high, with hooks. Length 0.34; height 0.28 mm. (see: Lea, Obs., VI, 1858, pl. 5, fig. 23; and Ortmann, 1911*b*, pl. 89, fig. 10).

Color of soft parts whitish, edge of mantle black, chiefly so posteriorly. The foot is pale brownish yellow, the gills grayish. The abdominal sac is often pinkish. The charged marsupium varies greatly in color, this variation depending at least in part on the stage of development of the embryos. It may be white, cream-color, pinkish, pale orange, or various shades of brown.

#### ***Symphynota viridis* (Conrad).**

Numerous specimens have been investigated from the Potomac, Susquehanna, and Delaware drainages of eastern Pennsylvania.

Breeding season from August to May.

Soft parts described by Lea (Obs., XIII, 1874, p. 71). They are in every particular identical with those of *S. compressa*. This species also is hermaphroditic (Ortmann, 1911*b*, p. 310), and specimens with the male structure of the gills have never been found. Glochidia (Lea, *ibid.*, pl. 21, fig. 4) are about of the same shape as those of the foregoing species, but slightly larger. Length 0.36; height 0.30 mm. Color of soft parts as in *compressa*; marsupium cream-color, pale orange, or brown.

#### ***Symphynota complanata* (Barnes).**

Eight specimens from northwestern Pennsylvania, collected by myself, have been investigated; in addition, three from the Kansas River, Lawrence, Douglas Co., Kansas (R. L. Moodie), and one from the Ohio at Portland, Meigs Co., Ohio (collected by myself). Among them were males, sterile and gravid females.

Breeding season not completely known, but the dates at hand agree with those of other species. Eggs were found in the marsupium in September.

Lea (Obs., X, 1863, p. 448) has described the soft parts; Simpson's (in Baker, 1898, p. 61) description is partly incorrect (scalloped edge

of marsupium). A figure of the gravid female has been published by Lefevre and Curtis (1910, pl. 1, fig. 6), but the essential structure of the marsupium is not brought out.

Mantle-connection between anal and supra-anal about as long as the anal, supra-anal slightly longer. In other respects, the soft parts are essentially identical with those of the other species of the genus. Glochidia of similar size, but shape more distinctly triangular, not so long in comparison with height. Length and height 0.34 mm. (see Lea, Obs., VI, 1858, pl. 5, fig. 29, and Lefevre and Curtis, *l. c.*, p. 97, fig. A. The measurements given by Lefevre and Curtis,  $0.29 \times 0.30$ , are at variance with mine; see also Ortmann, 1911b, pl. 89, fig. 11).

Color whitish when young, but foot and gills browner when old.

Abdominal sac brown-orange, marsupium pale yellow to brown.

### ***Symphynota costata* (Rafinesque).**

Many specimens from western Pennsylvania have been investigated, and two gravid females from Hurricane Creek, Gurley, Madison Co., Alabama (H. E. Wheeler, Sept. 13, 1910).

Breeding season from August to May. Eggs were found only in August and September.

Soft parts described by Lea (as *Margaritana rugosa*, Obs., X, 1863, p. 446) and Simpson (in Baker, 1898, p. 58).

Soft parts like those of *S. compressa*. It is noteworthy that the anal is very large, and the mantle-connection between anal and supra-anal comparatively short, much shorter than the anal. Glochidia (see Lea, Obs., VI, 1858, pl. 5, fig. 26; Lefevre and Curtis, 1910, p. 97, fig. B, length 0.35; height 0.39), larger, more distinctly triangular, higher than long. Length 0.34; height 0.37 mm.

This species is remarkable on account of its beak-sculpture, which does not conform to the double-looped type characteristic of this genus. In *S. costata*, the later bars (toward the disk) are rather heavy and straight, with hardly an indication of a sinuation. The earliest bars are concentric as usual. But between the earliest and the latest, are some bars, which show an indication of sinuation more or less well-developed.

This condition shows that we must not lay too much stress upon beak-sculpture as a general systematic character. *S. costata* is un-

doubtedly a *Symphynota*, but the beak-sculpture is abnormally developed. The situation of the bars, however, indicates that this species originally had double-looped sculpture.

Color of soft parts rather remarkable. Orange tints are often found, similar to those seen in certain forms of *Alasmidonta*. The ground-color is yellowish brown; foot, margins of mantle, and adductors, often deep orange. The gills are brown, the edge of the mantle, as usual, blackish. The marsupium, when charged, varies from yellowish to brown.

Genus *ARCIDENS* Simpson. (1900.)

Simpson, 1900b, p. 661.

Shell subrhomboid, inflated, with full beaks. Disk sculptured. Beak-sculpture strong, distinctly double-looped, the loops tubercular, and the tubercles are continued in two radiating rows upon the disk. In addition, there are oblique folds upon the disk, and the posterior slope is also sculptured. Hinge with teeth, pseudocardinals present and well developed, laterals obliterated, but traces of them may be seen.

Soft parts, as far as known, anodontine in structure, and similar to the genus *Symphynota*. Gravid females have not been observed.

Type: *A. confragosus* (Say).

The genus is incompletely known, but very probably it is to be placed near *Symphynota*.

*Arcidens confragosus* (Say).

I have one male and two females from Bayou Pierre, De Soto Parish, Louisiana, collected on Aug. 6, 1910, by L. S. Frierson, further the gills of an additional female from the same place, collected a little later, and one female from Pearl River, Jackson, Hinds Co., Mississippi, collected Nov. 5, 1910, by A. A. Hinkley. None of the females was gravid.

The soft parts of the male have been described by Lea (Obs., X, 1863, p. 448). Supra-anal long, well separated from the anal by a mantle-connection, which is shorter than the anal. Inner edge of anal crenulated, inner edge of branchial with papillæ. Diaphragm complete and normal. Inner lamina of inner gills free, except at

anterior end. Posterior margins of palpi connected for not quite one-half of their length.

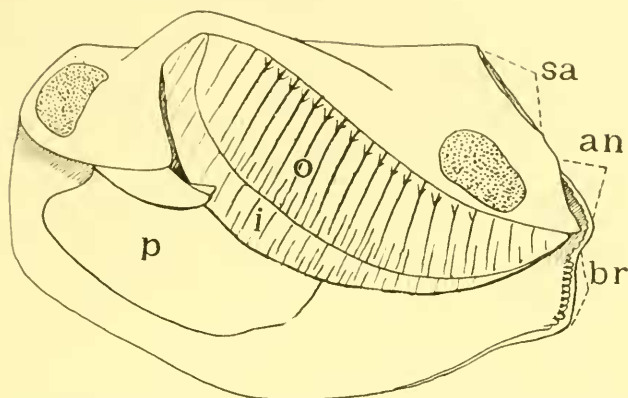


FIG. 12. *Arcidens confragosus* (Say). Male from Bayou Pierre, De Soto Parish, La. (Carn. Mus., No. 61, 4,701.)

Gills anodontine in structure. Simpson (1900b, p. 661) describes the marsupium in peculiar terms ("of a peculiar, granular texture"). Although I have not seen gravid females, the sterile females I possess offer nothing unusual or different from other *Anodontinæ*. Only the outer gills are marsupial, and their septa are much crowded, forming very narrow water-tubes, while in the inner gill the septa are much more distant. The septa of the outer gills are typically anodontine, and an indication of secondary water-tubes is present in the sterile female (see pl. XVIII, fig. 6). Besides, at the edge of the marsupial gill, there is a thick mass of tissue, which indicates, that in the gravid female the edge is capable of distending.

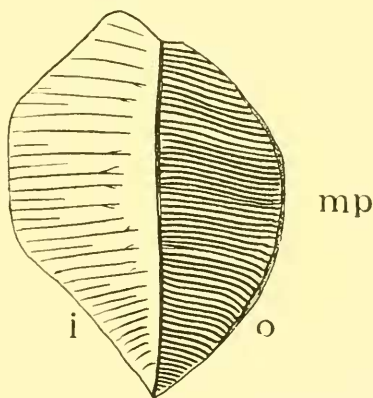


FIG. 12a. Left gills of a sterile female, from Pearl River, Jackson, Hinds Co., Miss. (Carn. Mus., No. 61, 4,928.)

## Genus ANODONTA Lamarck. (1799.)

Simpson, 1900b, p. 620.

Shell elliptical, or elongated; thin; flat, or inflated, with smooth disk. Beak-sculpture distinct, but not very heavy, of the double-looped type, the loops separated by a sinuation, or a reëntering angle. Hinge-teeth completely absent.

Only the outer gills are marsupial. When charged, the edge distends, and secondary water-tubes are present. Ovisacs not subdivided. No placentæ are developed. Inner lamina of inner gills free from abdominal sac. Mantle-connection between anal and supra-anal generally very long, longer than either opening.

Type *A. cygnea* (Linnæus).

In the reduction of the hinge-teeth, in the long mantle-connection between anal and supra-anal, and the whole structure of the shell, this genus represents a very extreme specialization of the anodontine type. In the free inner lamina of the inner gill it is rather primitive.

A large number of species are recognized by Simpson (1900b), but in Europe the species-making in this group has gone beyond all the bounds of reason. A healthy reaction is, however, setting in, with regard to this genus as well as the European genus *Unio* (see Kobelt, 1908, p. 91; Thiele, 1909, p. 33; Israël, 1909, p. 26; Haas, 1910c). As will be shown below, the European genus *Pseudanodonta*, which has been split off, is also unsatisfactorily supported. It remains to be seen, whether the species from western North America and Asia have the same structure of the soft parts. Certain Chinese forms differ in the beak-sculpture.

**Anodonta cygnea** (Linnæus).

See also Ortmann, 1911c, p. 22.

A large number of specimens of both sexes, including gravid females, from various places in Germany and Hungary have been sent to me by W. Israël.

I agree with Israël (1909) in regarding all *Anodontas* of central Europe (except *complanata*), as one species. The form *cellensis* is surely only the senile form of ponds, and *anatina* is the form of small creeks. The name of this species should be *cygnea* and not *piscinalis*.



Supra-anal and anal openings widely separated, the one about as long as the other, but the united part of the margin of the mantle

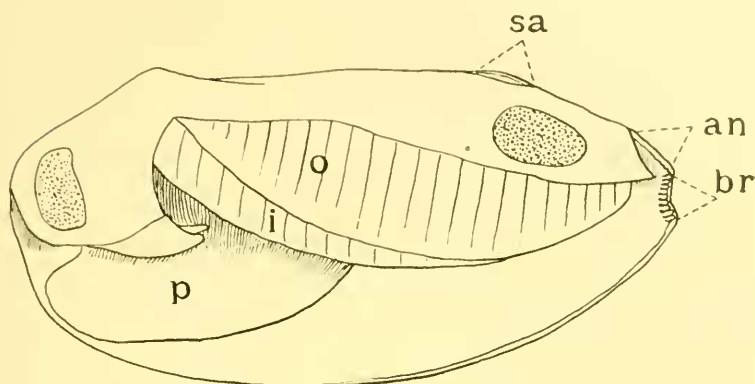


FIG. 13. *Anodonta cygnea* (Linnæus). Male, from Obra South Canal, Sepno, Prov. Posen, Germany. (Carn. Mus., No. 61, 4,956.)

between them longer than either, with slight variations in length. Anal with crenulations, branchial with papillæ. Palpi with the posterior margins united for one-fourth or one-third of their length. Gills and diaphragm as usual, inner lamina of inner gills free, except at anterior end.

In the male, the septa of both gills are rather distant; in the sterile female the septa of the outer gill are very crowded, forming very narrow water-tubes (see Plate XVIII, fig. 7). The whole outer gill is marsupial, and at its edge there is heavy tissue which permits the distending of the gill when charged. Within the marsupium each water-tube is divided, in the breeding season, into three tubes, two narrow lateral (secondary) water-tubes lying toward the faces of the gill, and a central larger

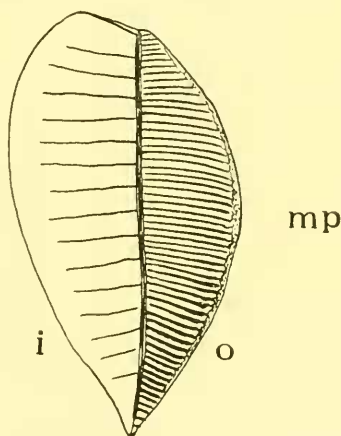


FIG. 13a. Left gills of a sterile female, from Mogelnitz River, Prov. Posen, Germany. (Carn. Mus., No. 61, 4,953.)

tube; the latter forms the ovisac, containing the eggs and embryos, and this ovisac is also closed at the base of the marsupium by a fine membrane.<sup>26</sup>

The eggs and glochidia fill the ovisacs without forming placentæ, and the glochidia are discharged through the anal opening in rather irregular masses. Glochidia<sup>27</sup> rather large, triangular, with hooks. They are about as long as high, 0.35 mm. (see Plate XIX, fig. 2).

Having seen only alcoholic material I refrain from describing the colors of the soft parts.

**Anodonta complanata** Rossmæssler.

See also Ortmann, 1911c, p. 22.

Six specimens from Dinkelsbuehl, Bavaria, and ten specimens from Buda-Pest, Hungary, are at hand, received from W. Israël. Among them are gravid females.

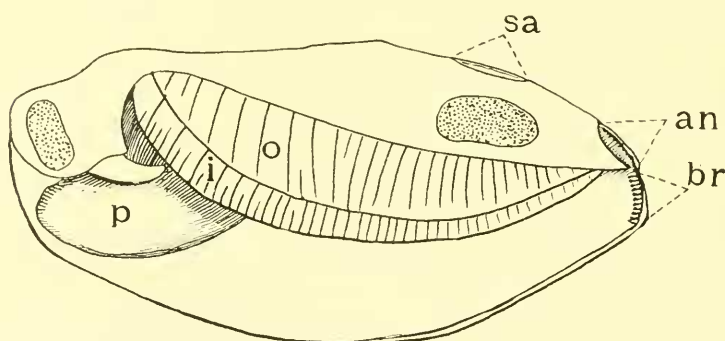


FIG. 14. *Anodonta complanata* Rossmæssler. Male, from Wœrnitz River, Dinkelsbühl, Bavaria. (Carn. Mus., No. 61, 4,958.)

Inner edge of anal opening with very fine papillæ. Gills (see Plate XVIII, fig. 9) essentially of the same structure as *Anodonta cygnea*,

<sup>26</sup> That the lateral water-tubes are actually parts cut off from the original water-tube by folds is conclusively shown by fig. 8, Plate XVIII. This is a slide made from a female, in which the eggs were just beginning to go into the marsupium. Attention should be called to the fact that in this species I never found the lateral water-tubes complete. This may be due to the fact that all my material was collected early in the breeding season. Nevertheless, some of the specimens had fully developed glochidia.

<sup>27</sup> The glochidia have been figured by Fleming (1875, pl. 4, fig. 4) and Schierholz (1889, pl. 2, fig. 26), their measurements, 0.35 mm., have been given by Harms (1909, p. 332) and Haas (1910a, p. 110).

but septa more irregular in the non-marsupial gills. In the marsupial gill of the female, the septa are crowded, even more so than in *A. cygnea*. The tissue of the gills is generally more delicate in *A. complanata*, but the various elements are similar to those of *A. cygnea*. The glochidia (see Plate XIX, fig. 3, also Schierholz, 1889, pl. 2, fig. 29; Fleming, 1875, pl. 3, fig. 11) are smaller, longer than high, with shorter hooks; thus the outline is less distinctly triangular, and less pointed. I find the length to be 0.34, the height 0.32; while Haas (1910a) gives 0.33 mm., but does not say in which dimension.

For this species, Bourguignat (1880, pp. 11-13) has created the genus *Pseudanodonta*, founded originally upon the shape of the shell and differences in the hinge. The first character is quite pronounced, but cannot be regarded under any condition as a generic character; the second does not exist at all, which is best shown by the fact that it has been dropped entirely by subsequent authors (Haas). Other writers have added to the distinctive characters, which have been

condensed by Haas (1910a, p. 110; and 1910c, p. 170). According to Germain, the beak-sculpture is said to be different.

*Pseudanodonta* is reported to have three to five tubercular ridges, which are absent in the true *Anodonta*, while in *Anodonta*, there are flexuous ridges, but never tubercular ridges ("les *Pseudanodontes* ont . . . trois à cinq rides tuberculeuses . . . qui manquent chez les véritables *Anodontes*. Chez les *Anodontes*, les sommets sont parfois ornés de rides flexueuses, mais jamais de rides tuberculeuses"). This statement is an intentional exaggeration of the actual conditions, worded with the purpose to obscure the similarities, and to emphasize the differences. The fact is that in both *Anodonta*

and *Pseudanodonta*, the beak-sculpture is of the same type, and consists of a number of double-looped bars, of which, in *complanata*, the posterior loop is slightly more swollen, but not tubercular. Haas also described the beak-sculpture of *Pseudanodonta* as "consisting of a few isolated, rather elevated tubercles," which is positively wrong, as is shown by the specimens before me.

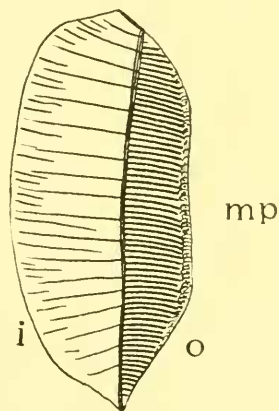


FIG. 14a. Left gills of a sterile female from same locality.

According to Clessin, differences are said to be present in the gills. Clessin (1876, p. 446) asserts that the tissue of the gills in *Pseudanodonta* is more delicate, that the transverse striæ ("Querstreifen") are more deeply incised, and that the less conspicuous longitudinal striæ ("Längsstreifen") are straighter and that the breeding compartments ("Brutfächer") are more quadrate ("bilden vollkommenere Quadrate").

The tissue of the gills is indeed more delicate, which is due chiefly to the slighter development of the interlaminar tissue. The gill-filaments are finer, and the interfilamentar grooves (probably the "Querstreifen" of Clessin) are deeper. What he calls "Längsstreifen," is probably produced by the longitudinal rows of water pores (ostia). Such a striation is indeed less distinct in a face view of the gills, in consequence of the stronger development of the filaments. They are not so distinctly visible as in *A. cygnea*, but nevertheless they are present. I cannot, however, under any conditions, see that they are straighter than in *A. cygnea*; on the contrary, they are slightly more irregular. What Clessin means by the statement that the "Brutfächer" are more quadrate, I cannot imagine. If he means the compartments formed by the septa, I can only say that, in a face view, they are not quadrate at all, either in *Anodonta* or in *Pseudanodonta*; if he means in a cross-section, they are quadrate or approximately quadrate only in the outer gill of the sterile female, both in *Pseudanodonta* and *Anodonta*, while in all other gills, non-marsupial gills of the male and female, and marsupial gill of the gravid female, they are in both genera anything else but quadrate.<sup>28</sup>

As has been said above, in *Pseudanodonta* the gill-structure is essentially the same as in the typical *Anodonta*, and all anatomical elements are present in both forms. The gills of *A. complanata* are indeed more delicate, chiefly in consequence of the slighter development of the interlaminar tissue; the gill filaments are finer, closer together, with deeper interfilamentary grooves, so that this layer on the outside of the gill is slightly thicker (compare Plate XVIII, figs. 7, 8, and 9). The consequence is that the rows of ostia, which are distinctly visible in *A. cygnea* in a face view, are rather indistinct in *A. complanata*. But when held up against the light, they also become distinct in the

<sup>28</sup> It almost appears as if Clessin had compared the marsupial gill of a sterile female of *Pseudanodonta*, with a non-marsupial gill of *Anodonta*. But I am not sure of this, since his terms are rather vague.

latter. Besides there is no difference whatever in the gills. The slight differences mentioned cannot be regarded, under any conditions, as of generic value, in face of the great similarity of structure. The presence of papillæ on the anal opening (Haas, 1910a, p. 110) in *Pseudanodonta* is a character, which at most has merely specific value. There remains only the glochidium (see Plate XIX, fig. 3) to be considered. There are, indeed, certain differences between the glochidia of *A. complanata* and *cygnea*, but as far as they are known in other members of the genus and subfamily, such differences are encountered elsewhere, without being considered as of generic value. The glochidia are undoubtedly built upon the same plan in both species.

*A. complanata* not only is a true *Anodonta*, but judging by the shape of the beak and beak-sculpture belongs to that *group* in the genus, of which *A. cygnea* is the type. We cannot separate it generically from the latter, without disregarding natural affinities.

#### ***Anodonta imbecillis* Say.**

I have investigated twenty-three specimens from northwestern Pennsylvania (Allegheny and Lake Erie drainages), and two from Lawrence, Douglas Co., Kansas (R. L. Moodie). All were females in structure, and many were gravid. This species is hermaphroditic.

Typically bradytictic, and gravid from September to May. In Lake Erie the time of discharging the glochidia is postponed even further, this act having been observed as late as July 12.

The anatomy has been described by Lea (Obs., X, 1863, p. 449).

Of all American forms this species resembles most closely the European *Anodontas* in the shape of the shell. It differs, however, in being hermaphroditic. The soft parts present no special features, and they agree both with the European *A. cygnea* and the North American *A. grandis*. The anal opening is almost smooth.

Glochidia smaller than those of *cygnea*, slightly higher than long (length 0.30; height 0.31 mm.), of the usual shape, with hooks (see Lea, Obs., VI, 1858, pl. 5, fig. 36; Ortmann, 1911b, pl. 89, fig. 13).

Color of soft parts whitish, foot yellowish brown; gills pale brown; edge of mantle blackish. Charged marsupium brown.

#### ***Anodonta henryana* Lea.**

Seven specimens from a branch of the Rio Grande, Mercedes, Hidalgo Co., Texas, collected May 15, 1907, by Dr. D. A. Atkinson.

Soft parts and glochidia described by Lea (Obs., VIII, 1860, p. 373).

I think my specimens belong to this species, although they are all remarkably shortened and truncated posteriorly. They are all gravid, with glochidia. Possibly this species also is hermaphroditic.

Soft parts absolutely identical with those of *A. imbecillis*, and the glochidia also are practically identical. Length 0.29; height 0.30 mm. (The difference from the measurements given for *A. imbecillis* may be due to the personal equation of the observer.) The shell of this species reveals that it undoubtedly belongs to the same group as *A. imbecillis*.

### **Anodonta grandis Say.**

Numerous specimens of the typical form as well as of several varieties have been investigated. They come from western Pennsylvania, Kansas, northern Alabama, and Louisiana.

The breeding season begins in August and September, and ends very early in spring, for in April the majority of the females have already discharged their glochidia. But occasionally gravid females are found as late as the end of May (latest date, May 22).

The soft parts have been described (as of *A. plana*, *decora*, *ovata*) by Lea (Obs., X, 1863, p. 452) and by Simpson (in Baker, 1898, p. 52, chiefly as to color).

Mantle-connection between anal and supra-anal very long, anal small, its inner edge crenulated. Branchial opening with papillæ, inner edge in front of branchial smooth. Posterior margins of palpi connected for one-third to one-half of their length. Anterior end of inner gills midway between that of the outer gills and the palpi, so that it is widely remote from the palpi. Diaphragm normal. Inner lamina of inner gills free except at anterior end. Septa of the gills distant in the male and the non-marsupial gills of the female. Marsupium formed by the outer gills, which swell greatly when charged, distending at the edges so as to appear truncated, and developing lateral water-tubes, while the ova are contained in the central ovisacs; the latter are not subdivided. No placenta are formed, and the glochidia are discharged loose, in irregular masses.

Glochidia very large, the largest known to me, even larger than those of *A. cygnea*, subtriangular, slightly higher than long (length 0.36; height 0.37 mm.) with hooks. The glochidia figured by Lea (Obs., VI, 1858, pl. 5, figs. 32-34) as of *A. lewisi*, *ovata*, *decora*, differ somewhat from each other, while they actually should be all alike.

Color whitish. Foot orange-yellow, palpi and gills brown. Edge of mantle brown, black behind. Charged marsupium yellowish white (with eggs) to liver-brown (with glochidia).<sup>29</sup> The orange tint of the foot is variable, lighter or darker.

**Anodonta cataracta** Say.

About twenty-five specimens from various places in the Atlantic drainage of eastern Pennsylvania have been investigated.

The breeding season begins in August, in which month I repeatedly found gravid females with eggs. I have no other observations of my own, but Conner (1907, p. 88) gives October to May as the breeding season.

Lea (Obs., II, 1838, pl. 15, fig. 46) has figured the animal, but his figure is practically useless.

The soft parts resemble in every respect those of *A. grandis*. I have seen the glochidia of specimens from the Delaware River, collected by C. H. Conner on March 19, 1911, and they agree with the figure published by Lefevre and Curtis (1910, p. 97, fig. C); the dimensions are: length 0.36; height 0.37 (identical with those of the glochidia of *A. grandis*). The colors of the soft parts are also the same.

I have my doubts as to the specific distinctness of this form from *A. grandis*. At any rate, it is merely the eastern representative of the western *grandis*, and does not have any close affinity to the European species and the *Anodontas* of the Pacific slope of America, as Walker (1910a, p. 135) believes, and there is no reason to think that "it was a co-immigrant with *Margaritana margaritifera* to the east coast of North America" (from Europe). *A. cataracta* is, if anything, an eastern offshoot of the *A. grandis*-stock of the central basin.

Genus ANODONTOIDES Simpson. (1898.)

(Simpson, 1900b, p. 658.)

Shell subelliptical, thin, inflated, with smooth disk. Beak-sculpture distinct, but not very heavy, consisting of concentric ridges curved up behind, not double-looped. Hinge-teeth absent, or represented by the merest rudiments.

Soft parts much like those of *Anodonta*. Outer gills alone marsupial, when charged distending at the edges, and secondary water-tubes present, ovisacs not subdivided. No placenta developed. Inner

<sup>29</sup> Sometimes the light color is preserved in the glochidial-stage.



lamina of inner gills free from abdominal sac. The mantle-connection separating anal and supra-anal shorter than in *Anodonta*.

Type *A. ferussacianus* (Lea).

This is practically an *Anodonta* with concentric beak-sculpture. The general make-up of the shell is much like *Anodonta*, while the beak-sculpture is suggestive of the *Alasmidonta*-group, without being so heavy.

***Anodontoides ferussacianus* (Lea).**

Numerous specimens of the typical form, as well as of the var. *subcylindraceus* (Lea) have been investigated, the former from the Ohio drainage in western Pennsylvania, and the Cumberland River in Kentucky, the latter from Lake Erie.

Bradyctic. The breeding season begins in August and ends in May; discharging specimens were found on May 14.

Soft parts described by Lea (Obs., X, 1863, pp. 449 and 451), and Simpson (in Baker, 1898, p. 73), but the latter is mistaken with reference to the marsupium of *ferussacianus*, while the description of that of *subcylindraceus* (p. 74) is correct.

Anatomy essentially that of *Anodonta*, but it should be mentioned that the mantle-connection between anal and supra-anal is only about as long as the anal as well as the supra-anal. The inner edge of the anal is finely, but distinctly papillose. The posterior margins of the palpi are only connected for a short distance, and the anterior end of the inner gill is about half-way between that of the outer gills and the palpi. The marsupium has the same structure as in *Anodonta*, and the glochidia (Ortmann, 1911b, pl. 89, fig. 12) are rather small for the subfamily, subtriangular, and about as long as high (0.32 mm.). They have hooks, although Lea (Obs., VI, 1858, pl. 5, fig. 35) figures and describes them as without hooks.

I find that by a singular oversight I failed to make any field-notes on the color of the soft parts of this species but from alcoholic material and according to my recollection it is grayish white with the foot and the gills inclining to brownish. The marsupium containing glochidia is brown.

Genus *ALASMIDONTA* Say. (1818.)

(Simpson, 1900b, p. 666.)

Shell elliptical, or generally rhomboidal, inflated, with a well-developed posterior ridge. Disk generally smooth, but sometimes

with a faint sculpture upon the posterior slope. Beak-sculpture heavy and coarse, the later bars are often very thick and swollen, concentric, often angled behind, not double-looped. Hinge with teeth, pseudocardinals always present, laterals present or absent; in the former case sometimes abnormally developed.

Only the outer gills are marsupial, when charged, distending at edges, secondary water-tubes present, and ovisacs not subdivided. No placenta developed. Inner lamina of inner gills free from abdominal sac, or more or less connected with it. Mantle-connection between anal and supra-anal not very long.

Type *A. undulata* (Say).

This genus is rather primitive, especially in the character of the shell, and stands on about the same level as *Symphynota*, representing another parallel branch, characterized by the heavy, concentric beak-sculpture. The tendency to a union of the inner lamina of the inner gills with the abdominal sac indicates a slight advance in structure.

#### ***Alasmidonta heterodon* (Lea).**

About thirty specimens collected in April near Philadelphia have been investigated. Among them were many gravid females. Conner (1909, p. 112) found this species gravid in February.

An imperfect description of the marsupium and the glochidia has been given by Lea (Obs., X, 1863, p. 442).

The soft parts do not offer anything remarkable. The mantle-connection between anal and supra-anal is shorter than the anal. Anal with crenulated inner edge. Inner lamina of inner gills free. Posterior margins of palpi connected for about one-half of their length. The anterior end of the inner gill is separated from the palpi, but nearer to them than to the anterior end of the outer gill. Marsupium typically anodontine in structure. Glochidia (Ortmann, 1911b, pl. 89, fig. 8) the smallest known to me in this subfamily. They are subtriangular, much longer than high, with strong hooks. Length 0.30; height 0.25 mm.

Color of soft parts whitish; charged marsupium brown.

This is in every respect the most primitive type known to me in this subfamily.

#### ***Alasmidonta minor* (Lea).**

One male, and one gravid female (with glochidia), from Cumberland River, Pineville, Bell Co., Kentucky, have been communicated to me by B. Walker.

Of this form I have only the soft parts, and their structure is like that of other species of this genus. The mantle-connection between anal and supra-anal is almost as long as the anal, and the supra-anal is only slightly longer than the mantle-connection. The anal is finely crenulated, and the branchial has papillæ. Posterior margins of palpi connected for a short distance. Inner lamina of inner gills free. Anterior end of inner gill about half-way between the palpi and the anterior end of the outer gill.

Marsupium as usual, with distended edges, and secondary water-tubes. Glochidia as small as in the foregoing species, and of the same shape. Length 0.30; height 0.25 mm. (see Plate XIX, fig. 4).

Color whitish, edge of mantle spotted with black and white in the region of the branchial, anal, and supra-anal. Marsupium brown.

I have had no opportunity to examine the shell of this species, but it seems that it is related to *A. heterodon*.

#### ***Alasmidonta undulata* (Say).**

Numerous specimens from the Atlantic drainage in eastern Pennsylvania have been in my hands.

The breeding season begins in the middle of July, and lasts till the middle of June, so that the end of one season, and the beginning of the next are not very far apart. Of specimens found in July, 18th and 22d, all had only eggs; while those found on June 14 (only two) had fully developed glochidia.

Soft parts typical. Mantle-connection between anal and supra-anal rather long, slightly longer than the anal and than the supra-anal. Branchial with papillæ, anal crenulated. Posterior margins of palpi connected for one-half or slightly less than one-half of their length.

Diaphragm normal. Inner lamina of inner gills entirely connected with the abdominal sac, and only in a few cases was a small hole observed at the posterior end of the foot. Anterior end of inner gill about half-way between the outer gill and the palpi.

Marsupium normal; when charged, having distended edges, secondary water-tubes, and undivided ovisacs. Glochidia (Ortmann, 1911b, pl. 89, fig. 9) moderately large, higher than long, with strong hooks. Length 0.34; height 0.36 mm.

Abdominal sac whitish; foot paler or darker orange-brown; palpi whitish to orange-brown. Gills grayish brown, shading into orange. Mantle transparent gray, shading into brownish or brownish orange.

on the margin anteriorly, into white posteriorly. Edge of mantle brown, posteriorly orange, mottled with black spots. Adductors grayish to orange. The orange tints are often rather pale, inclining toward grayish yellow. Marsupium charged with eggs pale yellow; with glochidia brownish.

***Alasmidonta marginata* (Say).**

Of this species, and of its eastern variety *varicosa* (Lamarck) a large number of specimens have been investigated, both from the Ohio and the Atlantic drainages in Pennsylvania.

Bradyctictic, breeding season beginning in August, and lasting until May. Discharging specimens have been found on May 3.

The anatomy has been discussed by Lea (Obs., X, 1863, p. 446) and Simpson (in Baker, 1898, p. 63).

Soft parts essentially like those of *A. undulata*, to which species it is indeed closely allied. The mantle-connection between anal and supra-anal is much shorter. I have found the inner lamina of the inner gills always connected with the abdominal sac, although Lea (*l. c.*) says that it is sometimes more or less free at the posterior end. Posterior margins of palpi connected at base only.

Glochidia (see Lea, Obs., VI, 1858, pl. 5, fig. 27) rather large, higher than long, with hooks. Length 0.33; height 0.36 mm.

Color entirely like that of *A. undulata*, with a strong tendency toward orange tints; posterior margin of the mantle spotted with black and orange. Marsupium, according to contents, yellowish white to brown.

Genus *LASTENA* Rafinesque. (1820.)

(Simpson, 1900b, p. 654.)

Shell elongated; not inflated; without distinct posterior ridge. Disk smooth. Beak-sculpture concentric, bars irregular, coarse, middle part nearly straight. Hinge with rudimentary teeth, pseudocardinals only vestigial, laterals absent.

Soft parts only of male and sterile female known, but as far as can be seen anodontine in structure. Inner lamina of inner gills free. Mantle-connection between anal and supra-anal rather short.

Type *L. lata* (Rafinesque).

According to the characters of the shell, this genus stands between

*Alasmidonta* and *Strophitus*. It has the beak-sculpture<sup>30</sup> of the genera of the *Alasmidonta*-group, and approaches *Strophitus* in the hinge. It is very much to be regretted that gravid females are not at hand, and that the structure of the charged marsupium and the glochidia remain unknown. The sterile females, which I have seen, make it clear that only the outer gills are used as marsupia, and that they have a structure like that found in sterile females of the *Anodontinae* in general.

***Lastena lata* (Rafinesque).**

I have received, from B. Walker, the soft parts of two males and two sterile females from the Cumberland River in Pulaski and Cumberland Cos., Kentucky.

Anal and supra-anal separated by a rather short connection of the mantle. Anal finely crenulated, branchial with papillae. Posterior margins of palpi connected for a short distance.

Gills and gill-diaphragm normal, and *not* as described by Simpson.<sup>31</sup> Gills long and rather narrow, the inner one decidedly wider in front, its anterior end distinctly in front and below the anterior end of the outer gill, but separated from the palpi by a short, but distinct interval (it is connected with the descending part of the mantle attachment line for about three-fourths of its length, while one-fourth is occupied by the interval). Posteriorly, *the gills do not project freely, but are entirely of the usual shape*. Inner lamina of inner gills free from the abdominal sac with exception of the anterior end.

Septa and water-tubes normally developed. Marsupium formed by the outer gills, with the water-tubes narrow, and the septa close together, thick, and with strongly wrinkled epithelium. In the females at hand, no indications of secondary water-tubes could be seen. The thickened tissue at the edge of the gill was also not well developed. Both specimens are small (under medium size, about 40 and 45 mm. long), and seem never to have been gravid.

Color (of alcoholic material) whitish, edge of mantle brown, black behind.

<sup>30</sup> This sculpture is somewhat variable. It begins with simple concentric bars upon which a few heavier bars follow, slightly sinuated in the middle and angled behind, and then follow a few more upon the disk, quite heavy, but indistinct. The latter are sometimes absent, and sometimes even the sinuated bars are very rudimentary. The sculpture resembles somewhat that of *Strophitus*.

<sup>31</sup> Simpson (1900b, p. 654) says: "inner and outer (gill) about alike in size and form, projecting free slightly behind."

## Genus STROPHITUS Rafinesque. (1820.)

(Simpson, 1900b, p. 616.)

Shell subelliptical, subovate, or subrhomboidal, inflated, with indistinct posterior ridge. Disk smooth. Beak-sculpture concentric, consisting of a few rather heavy bars curving sharply up behind, forming an angle there. Hinge-teeth quite rudimentary, only mere vestiges of pseudocardinals present, which sometimes disappear altogether.

Inner lamina of inner gills free, or more or less connected. Mantle-connection between anal and supra-anal rather short. Marsupium formed by outer gills, when charged having the edge distended and secondary water-tubes. But the ovisacs do not remain simple, and are subdivided into a number of compartments running cross-wise in the gill from face to face; each compartment containing the ova and glochidia is well defined; placentulæ solid, persistent until they are discharged.

Type *S. undulatus* (Say).<sup>32</sup>

This genus offers in the marsupial structure the highest specialization known among the *Anodontinæ*. In the hinge and the inner lamina of the inner gill we also see indications of a high stage of development. The beak-sculpture and other characters of the shell assign it a place in the *Alasmidonta*-series.

***Strophitus edentulus* (Say).**

I have examined a great many specimens from all over Pennsylvania, from the Ohio, as well as the Lake Erie, Delaware, Susquehanna, and Potomac drainages. I have also seen specimens from the Erie drainage in Huron Co., Ohio (O. E. Jennings coll.), from the Potomac drainage in Maryland (collected by myself), from Lawrence, Douglas Co., Kansas (R. L. Moodie), and of the form called *shafferiana* Lea, from the Cumberland River in Kentucky (B. Walker).

Bradyctic. The breeding season begins in July (earliest date July 11), and ends in April and May. Discharging specimens have

<sup>32</sup> It is not clear what the original *Anodonta undulata* of Say is. Most authors (including Simpson) have taken the common *Strophitus* of the Atlantic drainage for it; but this is not different from the western *edentulus* Say. Conner thinks he has re-discovered the real *undulatus* in the tide waters of the Delaware river, but I can only see a local form of *edentulus* in it (I have not seen its soft parts). The form I have investigated is surely the *edentulus* of Say.

been found on April 22 and 24, and May 6 and 11. The latest date for gravid females in spring is May 22.<sup>33</sup>

Lea (Obs., II, 1838, pl. 15, fig. 47) has published a very poor figure of the soft parts, and descriptions of the latter (Obs., X, 1863, pp. 450 and 453).

Mantle-connection rather short, shorter than the anal. Inner edge of anal crenulated, that of branchial papillose. Posterior margins of palpi connected at base only.

Diaphragm normal. Inner lamina of inner gills very variable. In most cases it is connected anteriorly for about one-half of the length of the abdominal sac, in other cases the connection is much longer, and not unfrequently the inner lamina is entirely connected. Anterior end of inner gill about halfway between that of the outer gill and the palpi. Septa of the gills distant from each other in the male and the non-marsupial gills of the female. The outer gill alone is marsupial, with much more crowded septa. When gravid, the gills swell greatly, distend at the edges, and lateral water-canals are formed. In addition, the ovisacs are divided into compartments as described above. Placentulæ containing two to ten (or more) ova or glochidia. The placentulæ and glochidia have been figured by Lea (VI, 1858, pl. 5, figs. 37 and 38). The latter are not very large, subtriangular, longer than high, and have hooks. Length 0.36; height 0.30 mm.

Color of soft parts quite variable, but with the same tendency as *Alasmidonta undulata* to have certain parts (foot, edge of mantle, and adductors) orange. Some specimens (chiefly young ones) are more or less uniformly grayish or yellowish white, while others exhibit all shades from yellowish through brownish orange to bright orange. Gills mostly paler or darker brown, shading to orange. Mantle edge blackish, with the same orange and black spots as *Alasmidonta undulata*. Marsupium, according to contents, pale yellow, or creamy, to brown.

#### Subfamily LAMPSILINÆ.

A large number of forms belong here, which, as far as we know, are all found in North America, extending southward into Central America. Indeed, Simpson associates with these a number of Asiatic and African

<sup>33</sup> According to Lefevre and Curtis (1911) the "interim" is in July in Wisconsin, probably corresponding to the higher latitude. In 1911 I found gravid and discharging females in West Virginia on May 11, 12, and 13, but on May 23, 24, and 25 no gravid females were any more seen.



genera (*Pseudospatha*, *Ilyriopsis*, *Chamberlainia*, *Cristaria*, *Lepidodesma*, *Pilsbryoconcha*), but of all these the soft parts are unknown, and we may entertain strong doubts as to their belonging here.

In order to understand the structure of the *Lampsilinæ*, and their further differentiation, we must recall their essential characteristics and their purpose. We have seen that the soft parts are accommodated to two functions: (1) owing to the extended breeding season (in bradytictic forms) that of securing the proper aëration of the gravid marsupium, (2) the discharge of the glochidia through the edge of the marsupium. The latter physiological character is unique, and is found only in this subfamily. The former occurs in the *Anodontinæ*, but we have seen that it is there brought about in another way.

Very likely the adaptations to these two peculiar functions are connected in a degree. We see that it is the general tendency among the *Lampsilinæ* to move the marsupium toward the edge of the gill, and even beyond the latter. This has the effect that it is removed, more or less, from the natural outlets, and comes in close contact with the outer water flowing over the gills. Under these conditions it is easily understood that the habit was acquired to discharge the glochidia not by the long way (the suprabranchial canals), but by the shortest, by making them go through holes in the edge of the marsupium (see Plate XVIII, fig. 10). Thus we may say that the lampsiline marsupium serves two purposes, and is built according to a type which meets first the necessity of aërating the marsupium, and which in consequence of the structure so assumed, made another peculiar way of discharge desirable.

To supply breathing water for the glochidia, however, is of chief importance, and thus the further differentiation within this subfamily is easily understood, when keeping this point in view. Allowance should be made for certain expressions used in the following statement, and they should be excused by my desire to make the facts as clear as possible.

Among the *Lampsilinæ*, there are at least four types of marsupial structure, which represent as many different attempts to find a way of supplying breathing water to the marsupium. They all agree in having as a common feature the extrusion of the marsupium beyond the edge of the gill, and its investiture by only a very thin membrane, so that osmotic processes are greatly facilitated. In addition, in three of these types, there is also developed the tendency to move the

marsupium toward the posterior part of the gills and the shell, in order to have it as close as possible to the branchial opening and the inflowing water.

Of the four types of marsupium, three are found only in comparatively a few forms, while the fourth is more widely distributed, and gives origin to a new line of development. The first three may be called rather indifferent attempts on the part of the forms concerned, to solve the problem. The problem has been solved by them, indeed, but the way in which they did it did not contain any further possibilities. In the fourth case, the attempt was more successful, and opened the way for a series of additional improvements.

1. In *one case* (*Ptychobranchus*), the marsupium remains in a primitive stage in this respect, that it is pushed only slightly beyond the edge of the gill, and is not moved backward, but occupies the whole gill. But here in order to insure proper aëration by increasing the surface of the marsupium, while the latter remains rather thin, the whole marsupium is thrown into a number of folds which permit the water to easily reach the ovisacs, which are subcylindrical and not much swollen.

2. In the *second type* (*Obliquaria* and *Cyprogenia*), the task has been accomplished by reducing the number of ovisacs. This would have had the result of restricting the number of ova that could be accommodated in the marsupium, but this disadvantage is counterbalanced by a tendency to greatly elongate the ovisacs, in the direction beyond the edge of the gill. This feature is only slightly developed in *Obliquaria*, while it reaches its greatest perfection in *Cyprogenia*, and here there is not room enough within the shell for the extremely elongated ovisacs and thus they have to coil up in a spiral.

3. In the *third type* (*Dromus*), the marsupium originally is rather simple, the ovisacs remaining subcylindrical or being only slightly compressed. Here a better aëration is accomplished by a peculiar arrangement of the glochidia within each ovisac. They are not distributed through the mass of the placenta, but are situated along the edge of the slightly compressed placenta, thus facing the outer walls of the marsupium, where they are nearer the breathing water. In addition *Dromus* has developed a peculiar warping and folding of the marsupium, which also apparently has the object of increasing the surface offered to the water. But this latter feature is exhibited only in old specimens. It reminds somewhat of the structure of *Ptycho-*

*branchus*, but I think it has been independently acquired, and does not indicate close relationship.

4. In the *fourth type* (all other genera), an entirely different arrangement to provide aëration for the marsupium has been effected. While in the first three types structural modifications of or within the marsupium are introduced to bring the glochidia close to the breathing water, here the marsupium itself remains rather simple, and it is the water supply which is increased and intensified.

The marsupium forms in this case a rather swollen, generally kidney-shaped mass, in which the ovisacs are transversely dilated, so as to give them a leaf-like shape. The tendency to locate the marsupium in the posterior part of the gill and to cause it thus to approach the posterior end of the shell, close to the branchial opening and close to the incoming water, is common to all these genera. In other respects, there is no further differentiation of the marsupium. But a new device begins to develop, having for its aim the increase of the flow of the water over the marsupium, and this is accomplished by special structures on the edge of the mantle, just in front of the branchial opening. In the simplest cases (*Obovaria*, *Nephronajas*, *Amygdalonajas*, *Plagiola*, *Paraptera*, *Proptera*), the inner edge of the mantle is only slightly dilated, forming a fine lamella, but the presence of a (muscular) thickening, and often of pigment, indicates, that the edge has here a peculiar function. In other genera (*Medionidus*, *Eurynia*, *Lampsilis*), this part of the inner edge of the mantle is greatly developed, and carries special appendages in the shape of strong papillæ or flaps, which have the function of producing by their contractions, a lively current of water over the surface of the marsupium, which lies immediately inside of them. Finally, in the genus *Truncilla*, the inner edge of the mantle, which also has papillæ, is removed from the outer edge, thus enclosing a separate compartment, which may possibly be regarded as a kind of reservoir.

Thus it becomes evident that of these four arrangements acquired by the *Lampsilina* to provide breathing water for the glochidia, the last was the most advantageous, because it included the possibility of further development and improvements such as we find realized in the various genera just mentioned.

5. There remains yet a *fifth type* of structure, that found in *Frier-sonia*. Here the marsupium is truly lampsiline, resembling somewhat the *Obovaria*-type, but it is not so swollen, and instead of being blunt,

the edge is here sharp. The water-tubes (ovisacs) have a peculiar curve backward toward a point near the posterior end of the marsupium. For the present, I cannot correlate this structure with any special function, and must leave it for future study to decide what the meaning of this feature is.

We may arrange the genera of this subfamily as follows:

- a*<sub>1</sub>. Marsupium thin, not kidney-shaped, ovisacs subcylindrical or very slightly compressed. Placentæ generally rather solid. Inner edge of mantle in front of branchial opening not distinctly differentiated. Shell rounded, ovate, or subelliptical, sometimes with outer sculpture. Male and female shells practically alike.

- b*<sub>1</sub>. Marsupium occupying the whole of the edge of the outer gill, folded. Placentæ subcylindrical, club-shaped, short. Shell subelliptical.

**Ptychobranchus.**

- b*<sub>2</sub>. Marsupium occupying only a part of the outer gill. Placentæ moderately elongated or very long, subcylindrical, or very slightly compressed. Shell more or less rounded, generally with tubercles.

- c*<sub>1</sub>. Marsupium consisting of comparatively few, elongated ovisacs, extending from near the base of the gill beyond its edge. Placentæ subsolid, subcylindrical.

- d*<sub>1</sub>. Placentæ moderately long, slightly curved. Marsupium just behind the middle of the gill.....**Obliquaria.**

- d*<sub>2</sub>. Placentæ very long, spirally coiled up. Marsupium in, or slightly in front of the middle of the gill.....**Cyprogenia.**

- c*<sub>2</sub>. Marsupium consisting of a large number of ovisacs, occupying the larger posterior section of the outer gill. Placentæ slightly compressed near base, tapering, and becoming subcylindrical toward the margin.

- d*<sub>1</sub>. Ovisacs straight. Placentæ almost entirely beyond the edge of the gill, subsolid. Glochidia much longer than high, arranged on the outer faces of the marsupium. Edge of marsupium blunt, in old specimens warped and folded. Shell rounded, disk nodular.

**Dromus.**

- d*<sub>2</sub>. Ovisacs strongly curved back in the distal part. Placentæ for a great part enclosed between the original gill laminae, not solid. Glochidia not longer than high, distributed uniformly through the placental mass. Edge of marsupium sharp, pointed behind, not folded. Shell subelliptical, disk smooth.....**Frierersonia.**

- a*<sub>2</sub>. Marsupium thick, more or less kidney-shaped, ovisacs dilated and compressed. Placentæ not very solid. Inner edge of mantle in front of branchial opening, more or less differentiated. Shell rounded, elliptical, or elongated, swollen or compressed, generally without any outer sculpture. Male and female shells more or less different in shape.

- b*<sub>1</sub>. Inner edge of mantle slightly lamellate and crenulated, but without distinct papillæ or flaps. Male and female shell differing only slightly in shape, sometimes hardly at all.

- c*<sub>1</sub>. Shell rounded, ovate, or subelliptical, without or with indistinct posterior ridge. Glochidia of normal size and shape, subovate.
  - d*<sub>1</sub>. Shell rounded or ovate, swollen. Epidermis brownish, rarely greenish, with indistinct rays.....**Obovaria.**
  - d*<sub>2</sub>. Shell subovate or subelliptical, compressed, or only slightly swollen. Epidermis greenish or yellowish, with more or less distinct rays.  
**Nephronajas.**
- c*<sub>2</sub>. Shell ovate, triangular, swollen, or subelliptical and compressed. Glochidia of abnormal size or shape.
  - d*<sub>1</sub>. Shell subovate or subtriangular, with a strong posterior ridge.
    - e*<sub>1</sub>. Glochidia of normal shape, but abnormally small size. Shell subovate or elongate.....**Amygdalonajas.**
    - e*<sub>2</sub>. Glochidia spatulate, with gaping margins, large. Shell subtriangular.....**Plagiola.**
  - d*<sub>2</sub>. Shell subovate or subelliptical, more or less compressed, often winged, without distinct posterior ridge.
    - e*<sub>1</sub>. Glochidia of normal shape, but abnormally small. Shell rather thin.....**Paraptera.**
    - e*<sub>2</sub>. Glochidia celt-shaped, with two spines on each valve. Shell thin or rather thick.....**Proptera.**
- b*<sub>2</sub>. Inner edge of mantle with papillæ or flaps. Male and female shell distinctly, and often greatly different in shape.
  - c*<sub>1</sub>. Inner edge of mantle parallel with and close to the outer edge. Shell ovate, elliptical, or elongated. Glochidia subovate.
    - d*<sub>1</sub>. Inner edge of mantle with papillæ.
      - e*<sub>1</sub>. Shell with nodulous plications upon the posterior slope.  
**Medionidus.**
      - e*<sub>2</sub>. Shell without sculpture.....**Eurynia.**
    - d*<sub>2</sub>. Inner edge of mantle forming a ribbon-like flap.....**Lampsilis.**
  - c*<sub>2</sub>. Inner edge of mantle in front of the branchial opening more or less remote from outer edge in the female. Shell variable, not ovate or elliptical. Glochidia almost semicircular.....**Truncilla.**

In all these genera, we have a beak-sculpture, which is rather rudimentary, and, when developed, either of the concentric or the double-looped type. Beak-sculpture in this subfamily is apparently a character becoming more or less obliterated, and thus cannot be used for general systematic purposes, although it is available as a subsidiary character in a few cases.

Genus *PTYCHOBANCHUS* Simpson. (1900.)

(Simpson, 1900*b*, p. 612.)

Shell subelliptical, somewhat elongated. Disk smooth, sometimes with ridges on the posterior slope. Beak-sculpture indistinct, consisting of a few ridges, the first concentric, the others slightly double-

looped. Epidermis brownish, usually painted with hair-like rays, forming here and there squarish spots. Hinge-teeth well developed. Male and female shell alike externally, but internally the female shell has an oblique depression for the marsupium.

Soft parts with the inner lamina of the inner gills variable, free, except at the anterior end, to entirely connected, with all intergrades between these two extremes. Edge of the mantle not differentiated in front of branchial. Marsupium formed by the whole of the outer gills, with more crowded septa than the non-marsupial gills. Ovisacs only slightly extended beyond the edge of the gill, occupying only the marginal part of the gill, rather short, subcylindrical, and club-shaped (swollen at distal end); the whole marsupium is thrown into a number of folds (six to twenty). Placentæ very solid. Glochidia suboval, rather small.

Type: *P. phaseolus* (Hildreth).

This genus, in many respects, is the most primitive among the *Lampsilinae*, but the folds of the marsupium represent a special structure.

#### ***Ptychobranchus phaseolus* (Hildreth).**

I have seen many specimens from the Ohio and Lake Erie drainages in Pennsylvania, and one gravid female from the Ouachita River, Arkadelphia, Clark Co., Arkansas (H. E. Wheeler, coll. Febr. 6, 1911).

Bradytictic, gravid from autumn to spring.

The soft parts have been described and figured by Lea (Obs., VII, 1860, pl. 29, fig. 101) and Lefevre and Curtis (1910, pl. 1, fig. 1).

Edge of mantle closed between the anal and supra-anal, the connection is short, but was never found missing. The branchial has papillæ, the anal is finely crenulated. In front of the branchial opening the inner edge of the mantle is first finely crenulated, but then becomes entirely smooth. Palpi of usual shape, their posterior margins connected for about one-fourth of their length.

Gills long and moderately wide, the inner the wider. Their anterior attachment as usual, with the end of the inner gill slightly in advance of that of the outer, but widely separated from the palpi. Diaphragm normal, inner lamina of inner gill very variable: generally it is more or less free, and may be attached to the abdominal sac only at the anterior end, or for a greater distance; but in one case (out of thirty-two) it was found to be entirely connected. Thus, in this species, this character is inconstant.

Septa of the non-marsupial gills as usual. Marsupium formed by the outer gills in almost their whole length; only small sections are left free anteriorly and posteriorly; but in young individuals larger sections are non-marsupial. In the basal half the whole outer gill is non-marsupial, and has rather wide water-tubes, but the marginal half becomes marsupial, with much narrower water-tubes (ovisacs), and along the edge of the gill the ovisacs bulge out beyond it. This bulging out is only moderate. The placenta are in the distal half of the gill; they are subcylindrical and club-shaped, being thicker toward the edge. The whole marsupium is thrown into a number of folds, increasing its surface, and further, in the distal part of the gill, the filaments are stretched or flattened out, so that the membranes enclosing the placenta become much thinner in this region than usual. Along the edge of the marsupium, the protruding ovisacs appear as a folded series of beads. The number of the ovisacs and of the folds is variable, and increases with age. Also in the sterile female the beads and folds are indicated on the edge of the marsupium.

Placenta quite solid and permanent. They are discharged whole through holes formed at the end of the ovisacs (repeatedly observed). A brown stain is developed in the placenta, chiefly on their surface, which possibly indicates a hardening of the gelatinous matter. The eggs and glochidia are imbedded uniformly through the placental mass, but they are most crowded at the swollen ends.

Glochidia (see Lea, Obs., VI, 1858, pl. 5, fig. 12;<sup>34</sup> and Ortmann, 1911b, pl. 89, fig. 14) rather small, subovate, without hooks, higher than long. Length 0.17; height 0.19 mm.

Color of soft parts whitish, foot grayish, gills whitish, or grayish brown. Edge of mantle brown, broadly black posteriorly. Marsupium, when charged, blackish or purplish brown, inclining sometimes more to blackish, sometimes more to purple. Beads at edge more vividly colored, red or purple. A line of black markings near the edge, immediately below the protruding beads, on each side.

<sup>34</sup> The poor quality of Lea's figures of the glochidia is clearly shown in this instance. The figure of the glochidium of *phaseolus* (fig. 12) stands next to that of *Eurynia recta* (fig. 11), and is distinctly larger than the latter, while actually the glochidium of *E. recta* is by far the larger of the two. Also the outlines of these two glochidia are not quite correctly rendered.



***Ptychobranchus foremanianus* (Lea).**

The soft parts of this species have been described by Lea (Obs., X, 1863, p. 443), and have been figured by him under the synonym *woodwardianus* (Obs., VII, pl. 29, fig. 103), and this species surely belongs in this genus.

***Ptychobranchus clintonensis* Simpson.**

This species also belongs here, as is shown by Simpson's description (1900a, p. 79).

***Ptychobranchus subtentus* (Say).**

Soft parts of one male and one gravid female were received from the Cumberland River, Burnside, Pulaski Co., Kentucky (B. Walker).

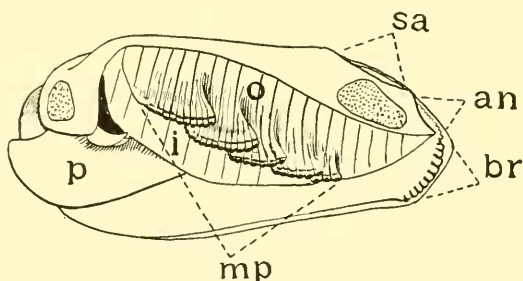


FIG. 15. *Ptychobranchus subtentus* (Say). Gravid female from Cumberland River, Burnside, Pulaski Co., Ky. (Carn. Mus., No. 61, 4,971.) (Anal and supra-anal conjectural.)

The soft parts of this species are entirely like those of *P. phaseolus*. The only difference I detect is in the extent of the marsupium, which consists of only five folds in my specimen, and does not occupy all of the outer gill, but leaves free a small section in front, and a somewhat larger one behind. Since I have only one female, I cannot tell whether this is always so, but I think it is unimportant, since likewise in *P. phaseolus* a considerable portion of the posterior end of the outer gill is non-marsupial in young individuals.<sup>35</sup> The anal seems to be almost smooth, and nothing can be said about the supra-anal, since these parts are badly injured in both specimens. Posterior margins of palpi connected only at base. Inner lamina of inner gills in both

<sup>35</sup> This is most noticeable in a young gravid female of *P. phaseolus* from Arkadelphia, Arkansas.

specimens free, except in front, where it is connected for a short distance in the female, and for a somewhat longer distance in the male. The glochidia are like those of *P. phascolus*, but slightly larger. Length 0.18; height 0.22 mm. (see Plate XIX, fig. 5).

The color of the soft parts is the same as in *P. phascolus*. Marsupium blackish purple, pale along the beaded edge, with black markings like those in *P. phascolus*.

This species is placed by Simpson (1900b, p. 591) in the genus *Medionidus*, but he states that the soft parts were unknown to him. If we disregard the peculiar sculpture of the posterior slope of this shell, the structure of the hard parts is very similar to that of *P. phascolus*. In some shells of *P. subtentus* in the Carnegie Museum I have even seen the slight depression inside of the shell, which corresponds to the marsupium.<sup>36</sup>

Genus OBLIQUARIA Rafinesque. (1820.)

(Simpson, 1900b, p. 610.)

Shell rounded oval, inflated. Disk with a row of large knobs, running from the beak to the center of the base, those of one valve alternating with the knobs of the other. Posterior slope corrugately sculptured. Beak-sculpture consisting of two or three rather heavy, but not sharply defined, concentric bars, which seem to be continued by the knobs of the disk. Epidermis greenish-yellow to brown, painted with numerous, delicate, wavy, and broken rays, which may be entirely absent. Male and female shells essentially alike.

Inner lamina of inner gills free, except at the anterior end. Edge of mantle not differentiated in front of the branchial. Marsupium consisting of a few (generally less than ten) ovisacs, occupying a position just behind the center of the outer gill, beginning near the base of the gill, and reaching far beyond the edge. They are large, subcylindrical, and slightly curved, and have the rather solid placenta of the same shape. Glochidia lying all through the placental mass, of medium size, almost subcircular.

Type *O. reflexa* Rafinesque.

*Obliquaria* is a primitive genus of the *Lampsilinae*, which, in order to solve the problem of the aëration of the glochidia, has reduced the

<sup>36</sup> Sterki (1898, p. 31, and 1903, p. 103) describes in *Ptychobranhus* "a deep, oblique sulcus on the inside of each valve in the female, the space occupied by the marsupium." This sulcus very often consists of a series of impressions corresponding to the marsupial folds. The same feature is observable in *P. subtentus*.

marsupium to a few ovisacs, compensating for the reduction in their number, by an increase in their length. The tendency to move the marsupium backward toward the branchial opening is but slightly indicated.

***Obliquaria reflexa* Rafinesque.**

Three males and one sterile female from the Ohio in Beaver Co., Pennsylvania, and another sterile female taken at Portsmouth, Scioto Co., Ohio, have been collected by myself. I received a sterile female from the Ouachita River, Arkadelphia, Clark Co., Arkansas, collected by H. E. Wheeler, February 6, 1911; and two males and four gravid females from Bayou Pierre, De Soto Parish, Louisiana, collected by L. S. Frierson, August 6, 1910.

Soft parts described by Lea (Obs., X, 1863, p. 429) and figured by Lefevre and Curtis (1910, pl. 1, fig. 3).

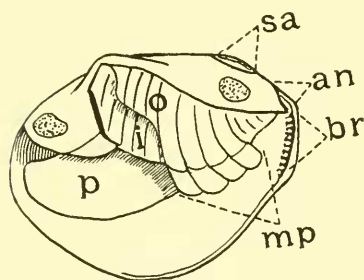


FIG. 16. *Obliquaria reflexa* Rafinesque. Gravid female, from Bayou Pierre, De Soto Parish, La. (Carn. Mus., No. 61, 4,755.)

Branchial, anal, and supra-anal as usual, mantle connection between the two latter moderately long, but shorter than the small anal. Branchial with papillae, anal crenulated. Toward the front the papillae of the branchial disappear suddenly, and the edge of the mantle is smooth, with a few indistinct crenulations just in front of the branchial. Palpi normal, their posterior margins connected only at base.

Gills short and broad, the inner wider anteriorly. Diaphragm normal; inner lamina of inner gills free from abdominal sac except at anterior end, where a portion less than half the length of the abdominal sac is connected. Anterior ends of gills normal.

Septa and water-tubes of both gills of the usual structure in the male. In the female, the marsupium is formed by a part of the outer gill lying just behind the middle of the gill, and not extending to the posterior end of it. The most characteristic feature is that the marsupium consists only of a small number (four to six in my specimens, but reported up to eight) of ovisacs, which, when empty, are hardly

narrower than the normal water-tubes, but have much heavier septa, with the usual marsupial structure of the epithelium. When charged the ovisacs swell so as to be considerably wider than the normal water-tubes. The marsupium protrudes beyond the original edge of the gill to a considerable degree, and the single ovisacs are subcylindrical, and are somewhat curved backward. The ova and glochidia fill the ovisacs in the shape of rather solid placentæ, and are packed close together through all of the placental mass (see Lefevre and Curtis, 1910, pl. 4, fig. 28). Probably the subcylindrical placentæ are discharged whole, although this has not been observed. The placentæ can be taken out whole (see *ibid.*, pl. 4, fig. 26), and in one of my specimens the holes through which placentæ had been recently discharged, have been seen (see Plate XVIII, fig. 10). The marsupium begins near the base of the gill, so that a considerable part of it is enclosed within the two original laminae of the gill.

Lefevre and Curtis (1910, p. 97, fig. M) have figured the glochidium, and give its dimension as  $0.225 \times 0.23$  mm. I find that this is substantially correct. The glochidia are of medium size, almost subcircular (their shape may be best compared with a circle a small section of which is cut off). Length and height about the same: 0.22 mm. (see Plate XX, fig. 1).

Color of soft parts whitish, with the edge of the mantle brownish, chiefly so in the region of the branchial and anal openings. Marsupium white.

There is much uncertainty as to the breeding season of this species. Lea (Obs., III, 1842) mentions ova as formed in the ovarium in autumn, and Sterki (1898, p. 20) found them in October. Lefevre and Curtis (1910, p. 89) place this species among the forms with a short breeding season, but without giving particulars. The sterile females collected by myself were all found in the month of September, at a time when most other bradytictic forms are gravid. The gravid females from Louisiana, collected by Frierson on August 6, were in part discharging, so that this would tend to show that the breeding season *ends* at that time. The statements made by Lea and Sterki might suggest that the breeding season begins rather late, in winter, and this assumption would agree with the facts at hand. Yet recorded observations are entirely too few, and attention should be directed to this question. The sterile specimen from Arkansas, collected in February, does not contribute to the solution of the question.

According to its known affinities and the gill-structure, this species should be bradytictic, and not tachytictic, as Lefevre and Curtis believe. But its primitive character makes it appear possible that in its breeding habits it may also be primitive, although I do not believe that it is a characteristic tachytictic form, for it possesses adaptations to a long breeding season.

Genus CYPROGENIA Agassiz. (1852.)

(Simpson, 1900*b*, p. 609.)

Shell rounded-triangular, inflated, often with a posterior ridge and a depression in front of it (especially in the young shell). Disk with nodular sculpture. Beak-sculpture obsolete (according to Simpson) slightly double-looped.<sup>37</sup> Epidermis greenish-yellow, painted with delicate rays, which break up into mottlings and spots. Male and female shell alike.

Inner lamina of inner gills free from abdominal sac, except at anterior end. Edge of mantle in front of branchial with fine crenulations, which soon disappear anteriorly, but without special structures. Marsupium consisting of rather few (generally less than ten) ovisacs, lying in the center, or a little before the center, of the outer gills. The ovisacs begin near the base of the gill, and reach far beyond the edge. They are extremely long, and coil up spirally, in a backward and inward direction. The placentaë are very solid, subcylindrical like the ovisacs, and spiral. Glochidia distributed all through the placental mass, of medium size, almost semicircular.

Type *C. irrorata* (Lea).

The structure of this genus can easily be traced back to *Obliquaria*. The same general plan is observed in the structure of the soft parts, except that the marsupium is unusually elongated, and, in order to be accommodated in the shell, it is coiled up.

#### **Cyprogenia irrorata** (Lea).

I collected, September 24, 1910, two males and one gravid female in the Ohio River at Portsmouth, Scioto Co., Ohio, and received from B. Walker, three gravid females from the Cumberland River in Cumberland Co., Kentucky.

No particulars as to the breeding season are known, but my specimen

<sup>37</sup> Although I have several specimens with tolerably well preserved beaks, I have never seen the beak-sculpture clearly.

from Portsmouth had eggs only, and thus the beginning of the breeding season is shown to be in autumn.

The soft parts have been described and figured by Lea (Obs., I, 1834, pl. 5, figs. 6 and 7; and Obs., X, 1863, p. 433), but the figure is very poor.<sup>35</sup>

Branchial, anal, and supra-anal as usual, the latter two separated by a very short mantle-connection. Branchial with papillæ, anal finely crenulated. In front of the branchial, the inner edge of the mantle has a series of fine crenulations which soon disappear, this edge becoming smooth. Palpi normal, posterior margins connected at base only.

Gills short and broad, the inner much wider than the

outer throughout its whole length. Diaphragm normal, inner lamina of inner gills free from abdominal sac, except at the anterior end. Anterior attachment of gills as usual.

Septa and water-tubes in both gills normally developed, the latter moderately wide in the male and the non-marsupial gills of the female. Marsupium formed by a section in the middle of the outer gill; in fact this section is a little more toward the anterior end of the gill. Ovisacs few (three to eight in my specimens; up to eleven reported by other authors; Simpson gives for the genus twenty-three as maximum), hardly different in width from the rest of the water-tubes, that is to say in the longitudinal direction. But, when charged, they swell somewhat in the transverse direction, so as to become subcylindrical. The ovisacs project to an extreme degree beyond the edge of the gill. Although they begin near the base of the gill, and although a considerable part is enclosed between the original laminæ of the gill,

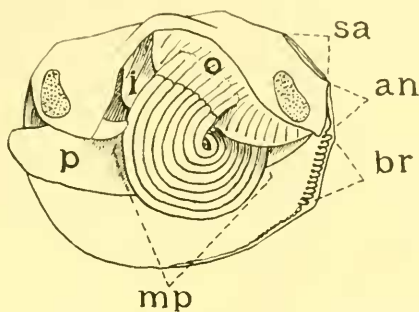


FIG. 17. *Cyrogenia irrorata* (Lea). Gravid female, from Ohio River, Portsmouth, Scioto Co., O. (Carn. Mus., No. 61, 4,763.)

<sup>35</sup> Lea's figures are quite characteristic of the marsupium itself, but the position of the latter in the animal (fig. 7) is wrong. Apparently the anterior and posterior ends of the body are inter-changed. The marsupium does not coil *forward*, as this figure shows, but *backward*.

this part is very small when compared with the prolonged portion. The latter curves backward in a circle, and is rolled up spirally, the spiral forming about one and a half to two turns, but only the posterior ovisacs complete the whole revolution, while the anterior ones stop earlier, the first after completing the circle about once. The distal parts of the spiral wind up in the direction toward the median line of the body, so that in a view from the outside, they are hidden under the outer gill and the first whorl of the marsupium.

The ova fill the ovisacs in the shape of closely packed masses, forming distinct and very solid placentæ, red in color, rarely white. Glochidia rather small, almost semicircular, distinctly longer than high, without hooks. Length 0.18; height 0.15 mm. (see Plate XIX, fig. 6). Sterki (1898, p. 19) gives the dimensions as length 0.21; height 0.17; diameter 0.14 mm. He also says that the glochidial shell is "considerably longer than high and has numerous distinct, crowded, concentric lines of growth." I have not seen the latter. The shape of the glochidia approaches to a degree, that of *Dromus*, but the disproportion between length and height is much less.

Color of soft parts whitish. Abdominal sac and mantle suffused with black. Edge of mantle brown with black spots, this mottling extending all around. Marsupium, when charged, red, or (according to Sterki) sometimes white.

#### Genus DROMUS Simpson. (1900.)

(Simpson, 1900b, p. 614.)

Shell very much like that of *Cyprogenia*. Beak-sculpture obsolete, described by Simpson as consisting of interrupted, concentric ridges, but I have never seen them distinctly.

Inner lamina of inner gills partly free from abdominal sac, connected near the anterior end for about one-third, or more, of the length of the abdominal sac. Edge of the mantle in front of branchial without special structures. Marsupium consisting of numerous ovisacs, which occupy the larger posterior portion of the outer gill, leaving a smaller anterior section non-marsupial. The ovisacs are comparatively short, subcylindrical, or only slightly compressed, and lie practically entirely beyond the original edge of the gill. In older individuals, the marsupium becomes warped and folded. Placentæ solid, subcylindrical, or slightly compressed, rather short. Glochidia placed chiefly toward



the outer walls of the marsupium, around the edges of the placentæ, which are central. Glochidia of peculiar shape, small, much longer than high.

Type *D. dromas* (Lea).

This is a highly interesting genus, with several quite unique features (general shape of marsupium, arrangement of glochidia and placentæ, shape of glochidia), but there is no question that it belongs to the more primitive types of the *Lampsilinæ*. In young specimens, where the marsupium is not folded, the marsupium resembles somewhat that of *Obovaria*, but without being so swollen. The general shape of the shell, as well as the shape of the glochidia can only be compared with that of *Cyprogenia*. I do not think that the folded marsupium indicates closer relationship to *Ptychobranchus*, since here the folds are of a different character. In the absence of special structures on the edge of the mantle, this genus shows only a low stage of specialization, without pointing to any particular affinity with other forms.

#### *Dromus dromas* (Lea).

I am indebted to B. Walker for seven complete specimens, and the soft parts of nine others, all from the Cumberland River, in Pulaski, Russell, Wayne, and Cumberland Cos., Kentucky. One of the soft parts was a male, the others were all gravid females with glochidia.

They all were collected late in the season of 1910, so that the beginning of the breeding season is in autumn.

The description of the marsupium given by Simpson (1900b, p. 615) is entirely inadequate and directly misleading, and in one particular ("bases of the ovisacs slightly rounded") unintelligible.

Anal opening separated from the supra-anal by a very short and deciduous mantle-connection: only in two young and one older specimen was the latter preserved; but the others had been rather roughly handled and the posterior region of the mantle was

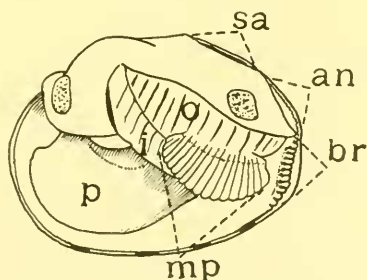


FIG. 18. *Dromus dromas* (Lea). Gravid female, young (shell 41 mm. long), from Cumberland River, Albany Landing, Cumberland Co., Ky. (Carn. Mus., No. 61, 4,970.)

generally more or less injured.<sup>39</sup> Anal large, with crenulations. Branchial large, with papillæ; toward the front papillæ gradually changing to crenulations, which soon disappear, so that the anterior inner edge of the mantle is smooth. Palpi of usual shape, but small; their posterior margins united for about one-half, or less, of their length.

Gills conforming to the shape of the shell, rather short and broad, the inner much the wider anteriorly. The anterior attachment of the gills is as usual. Gill-diaphragm normal. Inner lamina of inner gills free from abdominal sac, except anteriorly, where it is connected for about one-third to almost one-half of the length of the abdominal sac.

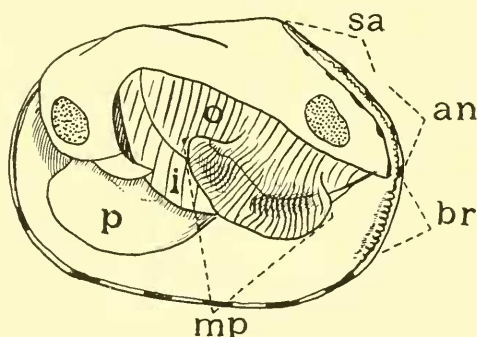


FIG. 18a. Gravid female, medium size (shell 55 mm. long), from Cumberland River, Eadsville, Wayne Co., Ky. (Carn. Mus., No. 61, 4,968.)

Gills with well-developed water-tubes and septa. Those of the male, and the non-marsupial gills of the female, with distant septa and wide water-tubes. Marsupium formed by the posterior section of the outer gill; more than half of the gill takes part in it; a larger section in front and a smaller behind remain non-marsupial. The marsupial part bulges out considerably beyond the original edge of the gill, about as wide again as the gill, and in this section the septa are much more crowded, and the ovisacs are narrow. When gravid, the ovisacs swell only slightly, so that they are very little compressed, and chiefly so near their base. The placenta have the same subcylindrical and only slightly compressed shape. Practically the whole of each ovisac

<sup>39</sup> But in some it was positively absent. This is also a rather primitive condition, not observed in any other form of the *Lampsilina*.

lies in the outbulging part of the gill, and only the basal ends extend very little in between the original gill-laminae.<sup>40</sup>

In young specimens, the marsupium is simple, and forms a smooth, compressed (not much swollen) body, marked off from the anterior and posterior non-marsupial parts of the gill by irregular folds. In larger specimens, however, this marsupial mass begins to warp, and finally is folded up into a number of irregular folds. The strongest folds are near the anterior end of the marsupium. In none of my specimens does the marsupium occupy the whole margin of the gill.

The placenta are quite solid and permanent, and possess a peculiar structure (see Plate XVIII, fig. 11). In all specimens at hand glochidia are developed, and they appear arranged around a central axis (placenta), the color of which is white or red. The latter color, if present, is restricted to this axis, and the glochidia themselves are transparent white, and form a fringe around the narrow edges of the placenta. They seem to be connected with them by fine threads, possibly their embryonal threads.<sup>41</sup> Since the placenta themselves almost touch the septa, the glochidia are thus crowded toward the lateral faces of the marsupium. Whether this arrangement is already present in the eggs, is unknown to me. It is, however, certain that this arrangement can only have the purpose of bringing the glochidia as close as possible to the wall of the marsupium, in order to give them the best chance to be near the current of fresh water going over the marsupium. This is one of the little special devices for the proper aëration of the glochidia.

Glochidia of unique shape; they are much longer than high, and

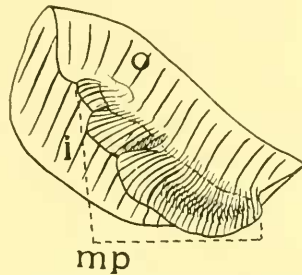


FIG. 18b. Left gills of a large gravid female (shell 60 mm. long), from Cumberland River, near Rowena, Russell Co., Ky. (Carn. Mus., No. 61, 4,966.)

<sup>40</sup> Simpson says that the marsupium occupies the "base" of the outer gills. This is a very ambiguous expression, but apparently is intended to imply that it is situated on the margin of the gills, while the "base" is non-marsupial. This is a very peculiar feature of *Dromus*, and not met with in any other genus. Only *Ptychobranchus* has the same condition slightly indicated.

<sup>41</sup> The glochidia adhere rather firmly to the placental mass by their threads and it is hard to isolate them, except with caustic potash.

might be called bean-shaped. No hooks are present. Length 0.19; height 0.10 mm. (see Plate XIX, fig. 7).

Color of soft parts whitish. Foot yellowish white, basal part (abdominal sac) gray or blackish. Gills gray or grayish white. In the gravid female, the marsupium is white or red. Mantle more or less suffused with black, whitish toward margins and front parts. Its edge has alternating chestnut-brown and black spots. Anal opening inside of this maculated edge with a white, followed by a black band.

Genus *FRIERSONIA* *gen. nov.*

Shell subelliptical, without distinct posterior ridge. Disk not sculptured. Beak-sculpture of the double-looped pattern, consisting of six to eight fine bars, of which the later ones are distinctly double-looped, and the latest are interrupted (unconnected) in the middle. Epidermis greenish-yellow, with rather distinct, simple rays. Male and female shells hardly different.

Inner lamina of inner gills connected with abdominal sac. Edge of mantle in front of branchial slightly lamellate, with fine and distinct crenulations, disappearing gradually in front, but without papillæ. A brown streak of pigment along this part of the edge. Marsupium consisting of many ovisacs, occupying the larger posterior section of the outer gill. When gravid, the ovisacs swell very little, and they are only slightly compressed in the basal part, which is largely enclosed between the laminæ of the gill. The ovisacs reach considerably beyond the edge of the gill, and in this region they are curved backward in a peculiar manner, subcylindrical, and tapering toward a point directed backward at the hind end of the marsupium. The marsupium has also a remarkably sharp edge. Placentæ not very solid. Glochidia lying all through the placental mass, of medium size, and subovate in shape.

Type *F. iridella* (Pilsbry and Frierson).

According to the arrangement in the key (p. 304) this genus would appear to fall into the same group with the preceding genera. But this is hardly the case. It has in common with the genera with which it has been associated in the key only the fact that the marsupium is *not* of the simple kidney-shape shown by the genera which follow in the key. The sharp edge of the marsupium, its posterior point, and the recurved ovisacs are quite unique. For the present, I do not understand the meaning of this structure, but it may be connected with the

discharge of the glochidia. In shell characters *Frieria* shows nothing very characteristic, but it approaches more nearly the *Nephronajas*- and *Eurytia*-types than any other.

***Frieria iridella* (Pilsbry and Frierson).**

*Lampsilis iridella*, Pilsbry and Frierson, 1908, p. 81 (figure published in 1907, on pl. 12); Pilsbry, 1909, p. 534.

I have the soft parts of three gravid females, one with eggs, two with glochidia, from Valles River, Valles, San Luis Potosi, Mexico, and owe them to the courtesy of L. S. Frierson. They were collected by A. A. Hinkley in December and January, 1906-1907.<sup>42</sup> *Cotypes of species.*

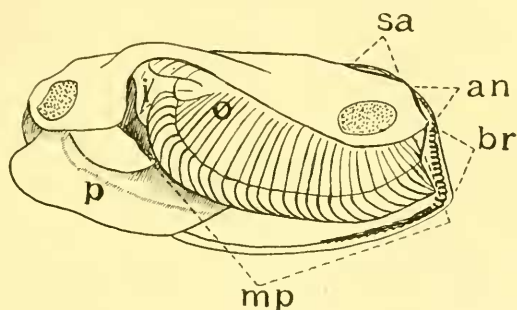


FIG. 19. *Frieria iridella* (Pilsbry and Frierson). Gravid female, from Valles River, Valles, San Luis Potosi, Mexico. (Carn. Mus., No. 61, 4,495.)

To the characters of the soft parts mentioned in the generic diagnosis the following should be added: Anal and supra-anal separated by a rather short mantle-connection (these parts are greatly injured in all three specimens, but the remnants of the connection may be seen in one specimen). Anal finely crenulated. Branchial with papillae. Palpi rather large, of usual shape, posterior margins connected about one-half of their length. Diaphragm and anterior attachment of gills normal. Gills of gravid female rather long, the outer marsupial gill covering all of the inner gill, except its anterior end. Septa and water-tubes as usual. Marsupium quite long, and formed by a greater part of the outer gill than usual, yet there is a portion at the anterior end and a very small one at the posterior end, which are non-marsupial. Ovisacs over fifty. The sharp edge of the marsupium

<sup>42</sup> See Hinkley, 1907, p. 68.

and the peculiar posterior point are quite evident in all three specimens, and the same is true of the peculiar curve of the ovisacs, so that these features cannot be accidental. Glochidia higher than long. Length 0.20; height 0.22 mm. (see Plate XIX, fig. 8).

Colors largely faded in my alcoholic material. One specimen has a peculiar brown line across the middle of the foot. The edge of the marsupium has brownish black pigment in spots.

This species and genus is one of the most peculiar with which I am acquainted. I would have considered it a *Nephronajas*, but since I have investigated another Mexican *Nephronajas* (see below), it is clear it cannot belong to this genus. The generic name is selected in recognition of the valuable help in my work received from Mr. L. S. Frierson.

Genus OBOVARIA Rafinesque. (1819.)

(Simpson, 1900*b*, p. 599.)

Shell rounded or ovate, higher than long, or only slightly longer than high, inflated, without distinct posterior ridge. Disk not sculptured. Beak-sculpture poorly developed, consisting of few subconcentric bars, of which the later ones have sometimes the tendency to become sinuate, but are not distinctly double-looped. Epidermis yellowish to brownish, rarely greenish, with indistinct, simple rays or without rays. Male and female shell slightly different in shape, the female being generally a little expanded on the post-base, but this difference is sometimes hardly noticeable.

Inner lamina of inner gills entirely connected with abdominal sac. Edge of the mantle very little differentiated in front of the branchial. It is slightly lamellar, with fine crenulations; and this part is generally emphasized only by the thickening of the margin of the mantle and the presence of a streak of dark pigment; there are never papillæ on it. Marsupium consisting of many ovisacs, occupying the posterior part of the outer gill. The ovisacs, when charged, swell transversely, so as to become lanceolate and compressed. They reach from near the base of the gill to, and a good deal beyond, the edge of the gill, and the whole marsupium assumes a kidney-shape. Placentæ not very solid. Glochidia all through the placental mass, of medium size and subovate.

Type *O. retusa* (Lamarck).

This is another primitive type of the *Lampsilinæ*, leading, however, toward the more highly developed forms of the subfamily. The

marsupium in this genus is not very peculiar, though assuming the characteristic kidney-shape of the higher *Lampsilinae*. The task of aerating the glochidia is taken up by the edge of the mantle in front of the branchial opening. However, the latter is as yet very little differentiated morphologically, but the thickened (muscular) margin and the pigment indicate that it actually has a special function. The shell of *Obovaria* presents no remarkable features, though it is possibly archaic, for it reminds of certain forms of *Fusconaja* and *Quadrula*.

This genus is divided by Simpson into two subgenera, which are very well defined.

Subgenus *Obovaria* (*sens. strict.*).

Shell rounded, rather upright, beaks more or less in the middle of the upper margin. Pseudocardinals normal and divergent.

Type *O. retusa* (Lamarck).

Subgenus *Pseudoön* Simpson (1900b, p. 601).

Shell ovate, oblique, beaks quite anterior. Pseudocardinals (at least in old shells) oblique, almost parallel to the laterals.

Type *O. ellipsis* (Lea).

At first glance, *O. ellipsis* looks very different from typical *Obovaria*, and I was for some time inclined to unite it with *Nephronajas*; but *O. castanea* clearly forms a connection with the typical forms.

Simpson (*l. c.*) describes the soft parts of *Pseudoön*, and says: "mantle having a wide, thickened, double border, the inner edge being toothed throughout below." This is incorrect. The inner edge is slightly widened and crenulated only for a short distance in front of the branchial. Simpson also says that the ovisacs are "tinted with purple below." I have not seen this in *O. castanea*, although *O. ellipsis* has a slight purplish gray pigment at the edge of the marsupium; but this should not be described as "purple."

### ***Obovaria retusa* (Lamarck).**

On August 29, 1908, I found a gravid female with eggs in the Ohio River in Beaver Co., Pennsylvania, and on September 22, 1910, I secured two males and two gravid females, with glochidia, in the Ohio River at Portland, Meigs Co., Ohio.

The soft parts have been described by Lea (*Obs.*, X, 1863, p. 433).

Anal and supra-anal separated by a short mantle-connection. Anal crenulated, branchial with papillæ. In front of the branchial the inner edge of the mantle in the female is slightly dilated and lamelliform,



with fine crenulations. It is defined on the inner side by a narrow stripe of black pigment. In the male this lamella is also present, but much weaker. Farther in front the edge of the mantle is smooth. Palpi small, normal, their posterior margins connected only at the base.

Gills short and broad, the inner ones broader. Diaphragm normal. Inner lamina of inner gills entirely connected with abdominal sac. Anterior attachment of gills as usual.

Septa and water-tubes in both gills normally developed. Marsupium restricted to a small section in the posterior half of the outer gill, leaving more than half of the anterior portion and a small posterior section non-marsupial. Ovisacs fifteen to twenty (in my specimens); when charged not narrower than the normal water-tubes in the longitudinal direction, but expanding in the transverse direction, so that their lumen becomes lanceolate and compressed, the whole marsupium thus appearing swollen and kidney-shaped. The marsupium extends considerably beyond the original edge of the gill, and about three-fourths of the length of the ovisacs is within the laminae of the

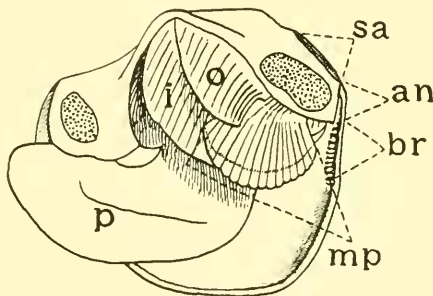


FIG. 20. *Obovaria retusa* (Lamarck). Gravid female, from Ohio River, Portland, Meigs Co., O. (Carn. Mus., No. 61, 4,773.)

gill, while one-fourth lies beyond the latter. Edge of marsupium blunt, without pigment. Placentæ not well developed; eggs and glochidia rather loose.

Glochidia rather large, suboval, without hooks. Length 0.22; height 0.27 mm. (see Plate XIX, fig. 9).

Color of soft parts whitish, only edge of mantle brown, with a black streak in front of the branchial. Charged marsupium whitish.

**Obovaria circulus** (Lea).<sup>43</sup>

About a dozen specimens from the Ohio drainage of western Pennsylvania have been investigated, among them gravid females. Several additional specimens were examined from the Ohio River in Ohio. Gravid females were found in the month of September, and on May 27. In the latter case, discharging individuals were secured, with holes in the edge of the marsupium.

Structure of soft parts essentially the same as in *O. retusa*. In the sterile female, the ovisacs are slightly narrower than the regular water-tubes. Number of ovisacs up to thirty and more. As in the preceding species the edge of the mantle in front of the branchial is in the female slightly lamellar and crenulated, but has only a brown (not blackish) mark along it.

Glochidia (see Ortmann, 1911b, pl. 89, fig. 15) similar to those of *O. retusa*, but smaller. Length 0.20; height 0.23 mm.

**Obovaria unicolor** (Lea).

I have received from A. A. Hinkley three males and eight gravid females, taken from the Pearl River, Jackson, Hinds Co., Mississippi, on Nov. 5, 1910. This species agrees in every particular with *O. circulus*, except that the glochidia are smaller. Length 0.16; height 0.21 mm. (see Plate XIX, fig. 10).

**Obovaria (Pseudoön) ellipsis** (Lea).

Two females were collected in the Ohio River in Beaver Co., Pennsylvania, on August 29, 1908, one sterile, the other just beginning to fill the marsupium with eggs. Three males, one sterile, and six gravid females were secured in September, 1910, in the Ohio River in Ohio. Thus the beginning of the breeding season is normal.

The soft parts are much like those of the other species of the genus. Anal and supra-anal separated for a short distance. Anal crenulated, branchial with papillæ. In front of the branchial the inner edge of the mantle of the female is slightly lamelliform, with fine crenulations. This part does not reach to the middle of the lower margin, and farther in front the edge is smooth. Posterior margins of palpi connected only at base. Inner lamina of inner gills connected with abdominal sac.

<sup>43</sup> This includes *O. lens* (Lea), which is not specifically distinct.

Marsupium formed by about the posterior half of the outer gill, kidney-shaped, consisting of as many as forty and more ovisacs, its edge slightly pigmented.

Glochidia similar to those of the other species. Length 0.19; height 0.22 mm. (see Plate XIX, fig. 11).

Color whitish, edge of mantle inclining to blackish, chiefly in the region of the branchial and anal, and more intense in the male sex. Pigment on edge of marsupium purplish gray, not sharply marked.

**Obovaria (Pseudoön) castanea (Lea).<sup>44</sup>**

Twelve males, one sterile, and five gravid females (with glochidia) from the Ouachita River, Arkadelphia, Clark Co., Arkansas, have been sent by H. E. Wheeler. They were collected on February 6 and March 21, 1911.

Identical in all essential respects with *O. ellipsis*. Marsupium formed by twenty to thirty ovisacs and its edge not pigmented. A grayish streak along the inner edge of the mantle in front of the branchial. Glochidia of the same shape as those of *O. ellipsis*, but smaller. Length 0.15 mm.; height 0.19 mm.

Genus NEPHRONAJAS Crosse and Fischer. (1893.)

(Simpson, 1900b, p. 591.)

Shell ovate or subelliptical, distinctly longer than high, compressed or slightly inflated, without, or with, indistinct posterior ridge. Disk not sculptured. Beaks moderately anterior, never in the middle of the shell, and never very near the anterior end. Beak-sculpture poorly developed, consisting of a few faint bars, which have a tendency to become double-looped, with the central part between the loops obliterated. Epidermis yellowish to greenish, generally with distinct

<sup>44</sup> There is some doubt as to the identity of my specimens. B. Walker has a number of sets of a shell from Alabama, Mississippi, Louisiana, and Arkansas, of which he sent me specimens, and some of which have been labeled by Simpson *castanea*, but which are certainly different from the present form, and probably do not belong to this genus at all. Although I have not seen Lea's type, I believe that I have the real *castanea*, for the reason that all authors (Lea, Obs., I, 1834, p. 91; Call, 1895, p. 9; Simpson, 1900b, p. 602) who have discussed this species, emphasize its similarity to *O. ellipsis*. Lea's words: "This small species is allied to *U. circulus* (nob.) in colour and to *U. ellipsis* (nob.) in form" are entirely sufficient to recognize it. There is no other form known to me, of which this could be said. Also Vanatta (1910, pp. 102 and 103) quotes *O. castanea* from the Ouachita River in Arkansas.

green rays. Male and female shells differing in shape, but the difference often hardly noticeable.

Soft parts agreeing with those of *Obovaria* in every respect; the glochidia also of the same type.

Type *N. plicatula* Charpentier.

In its anatomical structure this genus is indistinguishable from *Obovaria*. The differences are all in the shell. But while *Obovaria* is primitive in its shell, *Nephronajas* inclines toward the genera of the *Lampsilis*-type, in fact its species have been considered, at least temporarily, to belong to *Lampsilis*. The subgenus *Pseudoön* of *Obovaria* connects this genus with *Obovaria*, and so we have an almost complete series.

The nomenclature of this genus is doubtful. Of the species, which belong here, two (*ligamentina* and *perdix*) stand according to Simpson's system in *Lampsilis*, and a third (*sapotalensis*) in *Nephronajas*. Since *Lampsilis* is retained for other forms, only *Nephronajas* is available. But the anatomy of the type species of *Nephronajas* (*plicatula*) remains as yet unknown, and it is possible that it may differ in anatomy from *sapotalensis*. In the latter case, of course, *Nephronajas* could not be used for the present genus, and a new name would have to be chosen.

#### ***Nephronajas ligamentina* (Lamarck).**

Numerous specimens from the Ohio drainage in western Pennsylvania have been investigated. In addition specimens have been seen from the Ohio River in West Virginia and Ohio (collected by myself), from the Cumberland River in Kentucky (var. *gibba*), received from B. Walker, and from the Ouachita in Arkansas, received from H. E. Wheeler.

Typically bradyctic. The breeding season begins in August, and specimens with eggs are present in this month and the beginning of September. Later on only glochidia are observed. Specimens with glochidia have again been observed in May, and the discharge must take place in this month, for in June and July no gravid females have ever been found, although numerous specimens have been investigated.

The soft parts have been discussed by Lea (Obs., X, 1863, p. 424) and Simpson (in Baker, 1898, p. 108).

Anatomy in every particular like that of *Obovaria*. The inner edge

of the mantle of the female in front of the branchial is very slightly lamellate and finely crenulated. It is even less developed than is generally the case in *Obovaria*. The edge of the mantle is brown all around, often very pale, often darker, and becomes blackish in the region of the branchial and anal. Marsupium generally quite large and swollen, with as many as forty ovisacs, or even more. At its edge there is generally brownish or blackish pigment, but this may be indistinct, or even lacking. For an account of the glochidia see Lea, Obs., VI, 1858, pl. 5, fig. 18; Ortmann, 1911b, pl. 89, fig. 16. Length 0.22; height 0.24. Lefevre and Curtis (1910, pl. 4, figs. 24 and 27) have figured the placentæ, but they are distinguishable only when the eggs are present, later the cohesion is lost.

#### ***Nephronajas perdix* (Lea).**

I have received three gravid females from B. Walker. They are from the Cumberland River, Burnside, Pulaski Co., Kentucky.

This species agrees completely with *N. ligamentina*, and with *Obovaria* in general. In this species also the inner edge of the mantle of the female in front of the branchial is slightly lamellar and indistinctly crenulated, and emphasized by a streak of black pigment. Glochidia rather large. Length 0.25; height 0.29 mm. (see Plate XIX, fig. 12).

The affinity of this species with *N. ligamentina* has been recognized by Lea and Simpson, and thus it is not astonishing that the anatomy should prove to be the same.

#### ***Nephronajas sapotalensis* (Lea).<sup>45</sup>**

Three males, and two sterile females, from Hueyapam River, Hacienda de Cuatotalapam, Canton Alayucan, State of Vera Cruz, Mexico, taken July 23, 1910, have been examined. I received these specimens from A. G. Ruthven, and they belong to the Museum of the University of Michigan at Ann Arbor. One female has been kindly deposited in the Carnegie Museum.

<sup>45</sup> B. Walker writes to me about these specimens: they "agree exactly with Crosse and Fischer's figure of their *computatus*, which according to von Martens is probably only a variety of *sapotalensis*, differing mainly in having the pseudocardinals slender, while in *sapotalensis* they are heavy." The type locality of *sapotalensis* is Sapotal River, near Tlocatalpam, Mexico. This is not far from the locality of my specimens, and in the same general drainage system (Papaloapan and San Juan Rivers)-

In every respect like the two preceding species. Mantle-connection between anal and supra-anal shorter than anal, the latter with crenulations, the branchial with papillæ. Inner mantle edge of the female in front of branchial very slightly lamellate, with fine crenulations, and a black streak accompanying it. Palpi with posterior margins connected at base. Inner lamina of inner gills entirely connected with abdominal sac. Marsupium formed by numerous (twenty and more) water-tubes, occupying a section of the posterior half of the outer gill. In the sterile females at hand, the margin of the marsupium is rounded, projecting slightly beyond the edge of the gill, beaded, and marked with brownish black pigment. Placentæ and glochidia unknown.

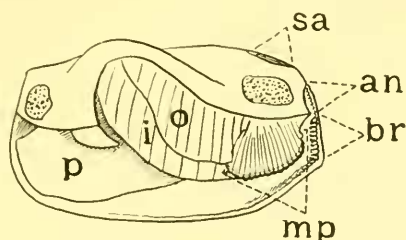


FIG. 21. *Nephronajas sapotalensis* (Lea). Sterile female, from Hueyapam River, State of Vera Cruz, Mexico. (Carn. Mus., No. 61, 5,000.)

Color whitish, with the margin of the mantle brown and blackish in the region of the anal and branchial, a blackish streak in front of the branchial, and black pigment on the edge of the marsupium.

Genus *AMYGDALONAJAS* Crosse and Fischer. (1893.)

Simpson, 1900*b*, p. 604 (as subgenus).

Shell ovate-triangular, inflated, truncated at posterior slope, with a distinct and often sharp posterior ridge. Disk not sculptured. Beak-sculpture consisting of a few fine ridges, of which the later ones are more or less distinctly sinuated or double-looped. Epidermis yellowish green, with a pattern of broken or arrow-marked rays. Male and female shells differing but little, the female shell somewhat inflated at the post-basal region.

Inner lamina of inner gills entirely connected, or free for a short distance. Inner edge of mantle in front of branchial in the female,

slightly lamellar for a certain distance, with fine crenulations. Marsupium apparently like that of *Obovaria* (I have seen only sterile females). Glochidia (according to Lefevre and Curtis, 1910, p. 97, fig. G), of suboval outline, but extremely small.

Type *A. cognata* (Lea), a Mexican species, of which the soft parts are unknown.

This genus stands close to *Obovaria* and *Nephronajas*, and has essentially the same structure of the soft parts. It differs, however, in the shape of the shell, and most emphatically in the glochidia. A final definition of the genus depends on the investigation of the anatomy of the type-species.

#### ***Amygdalonajas elegans* (Lea).**

Two males were found in the Ohio River in Beaver Co., Pennsylvania, by myself. From L. S. Frierson, I received three males and three sterile females from Bayou Pierre, De Soto Parish, Louisiana, collected Aug. 6, 1910.

The soft parts are described by Simpson (in Baker, 1898, p. 93).

Anal and supra-anal separated by a rather long mantle-connection, about as long as the anal. Anal crenulated, branchial with papillæ. In front of branchial, the inner edge of the mantle in the female is narrowly lamellar, with fine crenulations, this part reaching to about the middle of the lower margin. Posterior margins of palpi connected for about one-third of their length.

Gills and diaphragm of the usual shape. Inner lamina of inner gills sometimes entirely connected with the abdominal sac, sometimes free for a short distance (maximum about one-fourth the length of abdominal sac); often only small holes at posterior end of foot are left open.

Gills of the usual structure. In the female the marsupium is formed by the posterior part of the outer gills (a little over one-half). Ovisacs numerous, projecting beyond edge of gill. Charged marsupium not observed. The glochidia have been described and figured by Lefevre and Curtis (1910, p. 97, fig. G), and are characterized by their extremely small size. Length 0.075; height 0.09 mm.

Color of soft parts whitish, with the edge of the mantle blackish, mottled with black and white in the region of the branchial and anal. Along the inner edge in front of the branchial is a streak of black pigment.



Genus *PLAGIOLA* Rafinesque. (1819.)

(Simpson, 1900b, p. 603.)

Shell subtriangular, somewhat inflated, but peculiarly compressed toward the beaks, with a distinct posterior ridge, and a narrow, truncated, posterior slope. Disk not sculptured. Beak-sculpture indistinct, consisting of a few, fine, concentric, and slightly and indistinctly double-looped ridges. Epidermis yellow, greenish, or brownish, painted with rays, which are broken into lunate, or squarish, blotches. Male and female shells slightly different in shape, the female smaller, more inflated, and slightly swollen in the post-basal region.

Inner lamina of inner gills free for a greater or smaller distance. Inner edge of mantle in front of branchial for a certain distance slightly lamellar and with fine teeth, but without papillæ in the female. Marsupium like that of *Obovaria*, kidney-shaped. Placentæ lanceolate, not very solid. Glochidia very large, spatulate, gaping at the anterior and posterior margins.

Type *P. securis* (Lea).

In the soft parts, this genus stands essentially upon the same stage of development as *Obovaria* and *Amygdalonajas*. Its chief characteristics are the shape of the shell and of the glochidia. The latter are quite unique, and possibly indicate a transition toward the glochidia of *Proptera*.

*Plagiola securis* (Lea).

About half a dozen specimens from the Ohio and Allegheny in western Pennsylvania have been collected by myself. I received from B. Walker a gravid female from the Cumberland River in Kentucky, and another from H. E. Wheeler from the Ouachita River in Arkansas.

In September and October this species is regularly found gravid, so that the beginning of the breeding season is normal.

The soft parts have been described by Lea (Obs., X, 1863, p. 43).

Anal and supra-anal separated by a mantle-connection of medium length. Inner edge of anal crenulated, that of branchial with papillæ. In the female, the inner edge of the mantle in front of the branchial is slightly lamellar, with fine teeth, which are rather distant, but without papillæ. Posterior margins of palpi connected for about one-fourth of their length.

Gills and diaphragm of usual shape. Inner lamina of inner gills more or less free. The maximum observed was free for about three-

fourths of the length of abdominal sac, the minimum was only a small hole at the posterior end of the foot, but this was only on one side of the body; on the other side the lamina was free for a little less than half the length of the abdominal sac.

Gills of the usual structure. Marsupium kidney-shaped when charged, occupying the posterior half or more of the outer gill, with numerous (thirty and more) ovisacs, of the *Obovaria*-type. Ovisacs compressed, lanceolate, with poorly developed placentæ. Glochidia distributed all through the placentæ, of unusual shape (see Lea, Obs., VI, 1858, pl. 5, fig. 6;<sup>46</sup> Lefevre and Curtis, 1910, p. 97, fig. H; Ortmann, 1911b, pl. 89, fig. 17). They are quite large, subspatulate, (dilated and rounded off toward the ventral margin), and their anterior and posterior margins are distinctly gaping. Lefevre and Curtis give the measurements as follows: length 0.23; height 0.31; while my maximum measurements are: length 0.26; height 0.35 mm.

Color whitish. Edge of mantle brownish black, chiefly so in the posterior region. The black pigment is emphasized along the edge in front of the branchial.

Genus PARAPTERA Ortmann. (1911.)

(Ortmann, 1911b, pp. 301, 334, 338.)

Shell thin, elliptical, or obovate, when young with a distinct posterior wing, rather compressed, without posterior ridge. Disk without sculpture. Hinge-teeth feebly and often imperfectly developed. Beak-sculpture fine, consisting of a few concentric bars, followed by a few others, which are double-looped. In the latter, only the posterior loop is distinct, while the anterior is obliterated. Male and female shells slightly different, the female shell more expanded at post-base.

Inner lamina of inner gills entirely connected with abdominal sac. Edge of the mantle of the female slightly lamellar in front of branchial, with crenulations, but not with papillæ. Marsupium kidney-shaped, swollen, consisting of many ovisacs occupying the posterior part of the outer gills. Placentæ not very solid. Glochidia very small, of suboval shape.

Type *P. gracilis* (Barnes).

Another genus having the structure of *Obovaria*, distinguished only by the shape of the shell and the glochidia. The latter are very remarkable, and can only be compared with those of *Amygdalonajas*.

<sup>46</sup> This figure is not drawn to scale, and is much too small.

**Paraptera gracilis** (Barnes).<sup>47</sup>

I myself collected about a dozen specimens with soft parts in the Ohio and Lake Erie in western Pennsylvania, and received, from R. L. Moodie, a male from the Kansas River in Kansas, and from L. S. Frierson a male and a sterile female from Bayou Pierre, Louisiana.

The breeding season seems to have certain peculiarities. The species is undoubtedly bradyctic, but the season begins rather late. I found specimens with the marsupium partly charged as early as August 30, but these, as well as others found in September and October, all had only eggs, but no glochidia. In spring, a discharging female has been observed as early as May 22, but others were found fully charged with glochidia as late as July 7, 8, and 11.<sup>48</sup> Thus the breeding season must last from the end of August to about the middle of July, with only a very short interval.

Incomplete descriptions of the soft parts have been published by Lea (Obs., X, 1863, p. 434) and Simpson (in Baker, 1898, p. 99).

Anal and supra-anal separated by a mantle-connection which is slightly longer than the anal. Anal crenulated, branchial with papillæ. In the female the inner edge of the mantle in front of the branchial is lamellar, somewhat dilated, with fine crenulations, running forward for about one-third the length of the margin of the mantle. No papillæ are present. Palpi with the posterior margins united at the base only.

Gills and diaphragm of normal shape. Inner lamina of inner gills connected throughout with abdominal sac. Structure of gills normal. Marsupium formed by the posterior part of the outer gill, kidney-shaped, and swollen. Ovisacs numerous (thirty to forty), lanceolate. Placentæ not very solid, glochidia distributed all through the mass, very small, of suboval shape. Length 0.08; height 0.09 mm. (See

<sup>47</sup> Lea (Obs., VIII, 1862, p. 79, pl. 9, fig. 224) described *U. dolosus*, which Simpson (1900b, p. 568) makes a synonym of *U. purpuratus* Lea, but states that the glochidia are pouch-shaped (*Lampsilis*-type), not wedge-shaped as in *Paraptera purpurata*. Simpson dismisses this by saying (*l. c.*, footnote 2) that the "form of embryos in a given species is often not constant." This is a very serious mistake, for there is nothing more constant for the species than the glochidium. Call (1895, p. 19) makes *dolosus* a synonym of *gracilis*, and I think that he is right. Simpson (*l. c.*, p. 574) does not report *gracilis* from the Alabama drainage, but it surely is there (as *dolosus*). I have myself seen two specimens from the Coosa River at Wetumpka, collected by H. H. Smith in October, 1901.

<sup>48</sup> Those collected July 7 and 8 are from Lake Erie, but the one collected July 11 is from the Ohio River.

Lefevre and Curtis, 1910, p. 97, fig. K, where the measurements given are: length 0.07; height 0.09; Ortmann, 1911*b*, pl. 89, fig. 19, and Coker and Surber, 1911, pl. 1, fig. 2).

Soft parts whitish. Edge of mantle in the region of anal and branchial brownish black. A black streak runs along the inner edge for a certain distance in front of the branchial.

***Paraptera* (?) *fimbriata* (Frierson).<sup>49</sup>**

A gravid female (with eggs) from Valles River, Valles, San Luis Potosi, Mexico, was received from L. S. Frierson (*cotype*).

This specimen was collected in December, 1906, or January, 1907,<sup>50</sup> and the presence of eggs (beginning of breeding season) in "winter" should be noted.

I refer this species to this genus only tentatively. The structure of the soft parts is in every respect like that of *P. gracilis*. However, other genera have a similar structure. No glochidia were present, but the eggs are remarkably small (about 0.10 mm.), and this would indicate similarly small glochidia.

Further there is no doubt that *Lampsilis salinasensis* Dall (1909, p. 181, pl. 30, fig. 3) is the same species. This has been placed by Dall in Simpson's subgenus *Proptera* on account of shell-characters, and there is indeed much similarity of the shells, so that we may regard *P. fimbriata* as a *gracilis* less typically developed, with a stronger shell and better developed hinge-teeth. This species is certainly not a typical *Lampsilis* as shown by the absence of special structures on the edge of the mantle.

**Genus PROPTERA Rafinesque. (1819.)**

Simpson, 1900*b*, p. 566 (as subgenus).

Shell subsolid or rather thin, obovate or subelliptical, strongly winged behind, sometimes also in front, inflated or subcompressed, without distinct posterior ridge. Disk without sculpture. Hinge-teeth generally well-developed. Beak-sculpture much like that of *Paraptera*. Male and female shells slightly different, female more developed in the postbasal region.

Inner lamina of inner gills entirely connected with abdominal sac. Edge of the mantle in the female slightly lamellar in front of branchial,

<sup>49</sup> Frierson, 1907, p. 86, pl. 12.

<sup>50</sup> Hinkley, 1907, p. 68.

with crenulations, but without papillæ. Marsupium kidney-shaped, swollen, consisting of many ovisacs, occupying the posterior part of the outer gill. Placentæ not very solid. Glochidia rather large, celt-shaped, with two spines, one at each of the ventral corners.

Type *P. alata* (Say).

This genus stands in all characters except the glochidia, by the side of *Paraptera*. The shape of the glochidia is unique.<sup>51</sup>

### ***Proptera alata* (Say).**

About a dozen specimens from the Ohio and Lake Erie in western Pennsylvania have been studied, and a gravid female from the Kansas River in Kansas (R. L. Moodie).

The breeding season begins unusually early, eggs having been found in the marsupium on June 22. Glochidia have been seen in July, August, September, and October, and then again in May. This refers to specimens from the Ohio drainage. In Lake Erie, specimens with glochidia have been found in May, and discharging specimens as late as July 7 and 8. The beginning of the breeding season in Lake Erie has not been observed. Thus the end of one and the beginning of another breeding season seem to overlap, of course not in the same individual, and probably not in the same locality.

The soft parts have been described by Lea (Obs., X, 1863, p. 493) and Simpson (in Baker, 1898, p. 98).

It is hardly necessary to describe the anatomy in detail, since it agrees in every respect with that of *Paraptera gracilis*, with the exception of the mantle-connection between anal and supra-anal, which is here slightly shorter, and the glochidia. The latter (see Lea, Obs., VI, 1858, pl. 5, fig. 25; Lefevre and Curtis, 1910, p. 97, fig. D, and pl. 4, fig. 25; Ortmann, 1911b, pl. 89, fig. 18; and Coker and Surber, 1911, pl. 1, fig. 3) are so fundamentally different, that the creation of the genus *Proptera* is justified. Their dimensions are, according to Lefevre and Curtis: length 0.23; height 0.41. The specimens measured by me were not so large, being in length 0.20; height 0.38 mm.

<sup>51</sup> According to Coker and Surber (1911), *Lampsilis capax* (Green) has the glochidium similar to that of the species of *Proptera*. It should be ascertained whether the margin of the mantle of this species is that of *Lampsilis* or that of *Proptera*, before we assign it to *Proptera*.

***Proptera purpurata* (Lamarck).**

One male, and two sterile females from Bayou Pierre, De Soto Parish, Louisiana, have been sent by L. S. Frierson, and three males from Ouachita River, Arkadelphia, Clark Co., Arkansas, by H. E. Wheeler.

Description of soft parts given by Lea (Obs., X, 1863, p. 436).

This species is closely allied to the foregoing, and is its representative form in the south. The close relationship is borne out by the soft parts, which are absolutely identical. I have not seen the glochidia, but they have been described and figured by Lea (Obs., XIII, 1874, p. 73, pl. 21, fig. 13). They much resemble those of *P. alata*, but since Lea does not give the proportions, a closer comparison is impossible.

***Proptera lævissima* (Lea).**

I myself found a young male in the Ohio River, Portsmouth, Scioto Co., Ohio, and received, from R. L. Moodie, four males, and three gravid females from the Kansas River, Lawrence, Douglas Co., Kansas.

Soft parts described by Lea (Obs., X, 1863, p. 425).

Simpson places this species near *L. gracilis*, but the shape of the glochidia (see Plate XX, fig. 2) shows that it belongs to *Proptera*, and is related to *P. alata*. The soft parts, although similar in the genera *Proptera* and *Paraptera*, are more like *Proptera*, because of the shorter mantle-connection between the anal and the supra-anal. The glochidia are of the *Proptera*-type, but they differ distinctly from those of *P. alata* in being considerably smaller, and in having the ventral margin broader and more curved. The difference in shape is well expressed in Lea's figure (Obs., VI, 1858, pl. 5, fig. 24; see also Coker and Surber, 1911, pl. 1, fig. 1) while that of size is not. Length 0.12; height 0.18 mm. (Coker and Surber give length 0.095 mm.; height 0.15 mm.).

**Genus MEDIONIDUS Simpson. (1900.)**

(Simpson, 1900b, p. 588.)

Shell elongated. Posterior slope plicately or nodulously wrinkled. Beak-sculpture of the double-looped type, indistinct. Epidermis yellowish green, with green rays and blotches. Shell of the female different from that of the male, somewhat swollen just behind the middle of the base.



Inner lamina of inner gills free from abdominal sac, except at anterior end. Inner edge of mantle in front of branchial, with a series of rather distant, thin, but long, papillæ, resembling thick hairs. Marsupium formed by comparatively few ovisacs (six to eight), swollen, kidney-shaped, and occupying only a small part of the outer gill, immediately behind the middle. Ovisacs rounded at the end, projecting beyond the edge of the gill, not very sharply marked off from each other. Placentæ not solid. Glochidia subovate.

Type *M. conradicus* (Lea).

This is a doubtful genus. The description of the marsupium of *M. parvulus* (Lea, Obs., XI, 1867, p. 45) is similar to that of the type-species. In *M. penicillatus*, Lea (Obs., VII, 1860, p. 203) describes the marsupium as larger, but in a foot-note he mentions that in another specimen it was as small as that of *conradicus*. In *M. acutissimus*, the marsupium occupies, according to Lea (Obs., X, 1863, p. 411), the whole length of the gill. Simpson also says in the generic diagnosis, that the marsupium sometimes extends nearly the whole length of the gill. If thus the shape of the marsupium as described above should be inconstant, the most important generic character would be taken away, and *Medionidus* would fall as a synonym under *Eurynia*, with which genus it is indeed closely related in all other respects. Possibly in this case it would be best to make it a subgenus of *Eurynia*, on account of certain other peculiarities, such as the free inner lamina of the inner gills and the shell-sculpture.

#### ***Medionidus conradicus* (Lea).**

A male and a gravid female have been sent me by B. Walker, from the South Fork of the Cumberland River, Burnside, Pulaski Co., Kentucky.

Anal and supra-anal separated by a mantle-connection of medium length. Anal crenulated, branchial papillose. In front of the branchial the edge of the mantle carries in the female distinct, long, slender, hair-like papillæ almost as far forward as the middle of the lower margin. These papillæ are also present in the male, but considerably shorter. Palpi with the posterior margins connected at the base.

Diaphragm and gills of usual shape. Marsupium small, consisting of six to eight indistinctly separated ovisacs, forming an almost globular swelling just behind the middle of the outer gill. Glochidia rather large, subovate, or almost subspatulate. Length 0.22; height 0.28 mm. (see Plate XX, fig. 3).



Color of soft parts whitish. Margin of mantle brown all around, most intensely posteriorly. The edge of the mantle in front of the branchial and the papillæ are black, the black color extending broadly upon the inside of the mantle.

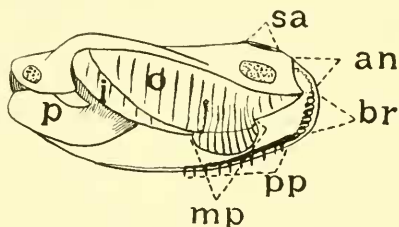


FIG. 22. *Medionidus conradicus* (Lea). Gravid female, from South Fork of Cumberland River, Burnside, Pulaski Co., Ky. (Carn. Mus., No. 61, 4,989.)

Both specimens at hand have a distinct *byssus* (the male is 18 mm., the female 27 mm. long). Compare Lea (Obs., X, 1863, p. 410; and *M. acutissimus*, *ibid.*, p. 411).<sup>52</sup>

Genus EURYNIA Rafinesque. (1820.)

Simpson, 1900b, p. 534 (as subgenus).

Shell subelliptical, often rather elongated. Outside of shell not sculptured. Beak-sculpture of the double-looped type, rarely sub-concentric, often quite obsolete. Epidermis generally yellowish or greenish, with more or less distinct rays, rarely darker and blackish. Shell of the female quite distinct from that of the male, more or less swollen, or expanded in the post-basal region.

Inner lamina of inner gills generally wholly connected with abdominal sac, rarely more or less free. In the female the inner edge of the mantle in front of the branchial has always distinct papillæ, which may be large or small, more or less numerous, and differently arranged. In the male a similar structure is observed, but in a rudimentary condition.

<sup>52</sup> A byssus-thread is frequently found in young *Unionida*, as observed by various authors and myself. This is undoubtedly a *real* byssus. Whether it is in any way connected with the embryonic "byssus" or larval thread, remains to be ascertained. According to Lillie (1905, pp. 52-54) the latter is not homologous to the byssus of other Lamellibranchiata, and is a larval organ serving originally the function of excretion and secondarily the function of attachment. In *Medionidus*, the byssus seems to be almost regularly present, and to be persistent. In other species (*Nephronajas ligamentina*, *Lampsilis ventricosa*, and others) where I have seen it, it is present only in young specimens. See also Isely (1911, p. 77).

Marsupium kidney-shaped, swollen, formed by many ovisacs, occupying the posterior part of the outer gill. Edge of marsupium blunt, projecting beyond the original edge of the gill, beaded, often pigmented. Placentæ not solid. Glochidia subovate, of medium size, or rather large.

Type *E. recta* (Lamarck).

This genus represents typically that group of the *Lampsilinæ*, in which the aëration of the glochidia is regulated by special structures on the edge of the mantle in the shape of papillæ. These papillæ show several distinct types of arrangement, and according to them (together with other characters) subgenera may be distinguished.

1. Subgenus **Carunculina** Simpson, 1898 (see Simpson, 1900b, p. 563).

On the edge of the mantle, in front of the branchial, a rather short group of crowded papillæ, resembling a caruncle. Inner lamina of inner gills more or less free from abdominal sac. Beak-sculpture concentric, rather distinct, bars curving up behind and somewhat angular.

Type *E. parva* (Barnes).

The beak-sculpture is so peculiar in these forms that *Carunculina* might be entitled to generic rank.

2. Subgenus **Micromya** Agassiz, 1852 (see Simpson, 1900b, p. 524).

On the edge of the mantle in front of the branchial there is a shorter or longer row of rather irregular, larger and smaller papillæ, reaching not quite to the middle of the lower margin. Inner lamina of inner gills connected with abdominal sac, or more or less free. Shell small, or of medium size, subovate, or subelliptical, not very long, and not much pointed behind. Beak-sculpture distinctly sinuated or double-looped, but often obsolete; the posterior loop often showing a tendency to be open.

Type *E. fabalis* (Lea).

Simpson has two species in his genus *Micromya*, *M. fabalis* and *cælata* (Conrad). The anatomy of the latter is unknown. The type-species has a structure essentially identically with a number of species, which stand in Simpson's *Lampsilis*. Since the latter name is used here in another sense, the name *Micromya* becomes available for this assemblage of species.

3. Subgenus **Eurynia** (*sens. strict.*).

On the edge of the mantle in front of the branchial a long row of quite regular, uniform, smaller or larger papillæ, reaching to about the middle of the lower margin. Inner lamina of inner gills connected with abdominal sac, but a small hole at the posterior end of the foot is sometimes left open. Shell of medium size or large, subelliptical, elongated, more or less pointed behind. Beak-sculpture sinuated, or double-looped, the posterior loop often open behind.

Type *E. recta* (Lamarck).

**Eurynia (Carunculina) parva** (Barnes).

Three gravid females, from the outlet of Conneaut Lake in Crawford Co., Pennsylvania, are at hand.

These specimens were collected on June 17, 1909, and contained only eggs and no glochidia, thus showing that the breeding season must begin unusually early.

The soft parts have been described by Lea (Obs., VII, 1860, p. 221) and a figure is given (pl. 29, fig. 102), which shows the shape of the marsupium and the position of the "caruncle." Other descriptions of the soft parts are those of Call (1895, p. 35) and Simpson (in Baker, 1898, p. 110).

As I have previously stated (Ortmann, 1911*b*, p. 314) a very small supra-anal seems to be present in one of my specimens, while in the others it appears entirely closed. No additional material has come to hand. The anal is finely crenulated, the branchial has papillæ. In front of the branchial, the inner edge of the mantle carries a group of distinct and crowded papillæ of various sizes (see Ortmann, 1911*b*, p. 317) occupying only a short space on the edge of the mantle, which further in front is smooth. Palpi connected at base only.

Diaphragm and gills of usual structure. Inner lamina of inner gills free for more than one-half of the length of the abdominal sac. Marsupium kidney-shaped, occupying about the posterior half of the outer gill, formed (in my specimens) by eleven to sixteen beaded ovisacs, projecting beyond the gill.

Glochidia not observed. They have been figured by Lea (Obs., XIII, 1874, pl. 21, fig. 2), and have the usual subovate shape found in this genus.

Color of soft parts whitish. Anal and branchial with brown and black margins. Group of papillæ brown-black, with a black mark on

its base upon the mantle. My specimens show no pigment at the edge of the marsupium.

***Eurynia (Carunculina) texasensis* (Lea).**

I have only the soft parts of a male, sent by L. S. Frierson from Bayou Pierre, De Soto Parish, Louisiana.

In this species a distinct supra-anal is present, longer than the mantle-connection, which equals the anal. Inner lamina of inner gills free from the abdominal sac for more than half the length of the latter. In front of the branchial there is a group of fine, crowded papillæ, accompanied by a black mark. This structure indicates that the female probably has a "caruncle" similar to that of *E. parva*.

In other respects, there is revealed no appreciable difference from the latter species, but the female is as yet unknown.

***Eurynia (Carunculina) paula* (Lea).**

***Eurynia (Carunculina) glans* (Lea).**

These two species belong here according to Lea's description (Obs., X, 1863, pp. 402 and 405).

***Eurynia (Micromya) fabalis* (Lea).**

Three males and one sterile female from the Ohio drainage of western Pennsylvania have been investigated.

The soft parts have been described by Lea (Obs., X, 1863, p. 423).

Anal and supra-anal are separated by a mantle-connection of moderate length, shorter than the anal. Anal crenulated, branchial with papillæ. In front of the branchial, there are in the female upon the inner edge of the mantle from eight to ten moderately large, subconical papillæ, somewhat distant from each other, extending forward a certain distance, but not to the middle of the lower margin. (See Ortmann, 1911b, p. 317.) They are accompanied by a streak of black pigment. Palpi connected only at base of posterior margins. Inner lamina of inner gills free for one-fourth to one-half of the length of the abdominal sac (differing in this from other species of the subgenus).

Marsupium formed by the posterior part of outer gills (a little less than one half of the length), a very small portion non-marsupial at posterior end. Ovisacs at least seventeen. Charged marsupium and glochidia not seen. Edge of marsupium whitish in my specimen.

In the male, the structure is similar, but the papillæ on the edge of the mantle are very small.

Color of soft parts whitish, edge of mantle brownish black, most intense behind, with a black streak along the base of the papillæ.

**Eurynia (Micromya) trabalis** (Conrad).

Three complete specimens and the soft parts of nine others from the Cumberland River in Pulaski, Wayne, and Cumberland Cos., Kentucky, have been received from B. Walker; from the same source came five other soft parts from Obey River, Celina, Clay Co., Tennessee. All are gravid females with glochidia.

On the inner edge of the mantle in front of the branchial are ten to fourteen subcylindrical papillæ of medium size, which are distant from each other, subequal, with a few smaller ones between them and in front of them. Inner lamina of inner gills connected with abdominal sac. Marsupium formed by about the posterior half of the outer gill, with an unusually long section non-marsupial at the posterior end. Ovisacs eight to twenty-four. Edge of marsupium broadly and intensely black. Glochidia rather large, subovate. Length 0.22; height 0.27 mm. (see Plate XX, fig. 4).

All other characters are like those of *E. fabalis*.

**Eurynia (Micromya) vibex** (Conrad).

I have investigated a sterile female of the var. *nigrina* (Lea) from Lake Monroe, Sanford, Orange Co., Florida, collected by O. T. Cruikshank in April, 1907.

On the inner edge of the mantle in front of the branchial there are about ten subcylindrical, subequal papillæ of medium size, rather distant from each other, with a few smaller ones anteriorly and posteriorly to them, not reaching the middle of the lower margin. Marsupium formed by about the posterior half of the outer gill. Ovisacs twenty, with blackish ends. Charged marsupium and glochidia unknown, but the latter have been figured (as of *U. rutilans*) by Lea (Obs., VI, 1858, pl. 5, fig. 4).

In other respects this species is like *E. trabalis*.

**Eurynia (Micromya) lienosa** (Conrad).

I have three males and three gravid females (with glochidia) from Pearl River, Jackson, Hinds Co., Mississippi, collected by A. A.

Hinkley, Nov. 5, 1910; and two males from the Ouachita River, Arkadelphia, Clark Co., Arkansas, collected by H. E. Wheeler, Feb. 6, 1911.

In front of the branchial there are about ten to twelve cylindro-conical papillæ of medium and unequal size, the smallest near the branchial, the largest forward. They are slightly distant from each other, and stop suddenly before reaching the middle of the lower margin. Marsupium formed by the posterior half (or more) of the outer gill. Ovisacs fifteen to twenty-two. No black pigment on margin of marsupium. Glochidia rather large, subovate. Length 0.20; height 0.27 mm. (see Plate XX, fig. 5).

In all other respects like *E. trabalis* and *E. vibex*.

### *Eurynia (Micromya) iris* (Lea).

Four males one sterile and six gravid females have been investigated, coming from the Ohio and Lake Erie drainages in western Pennsylvania.

Gravid females have been found in the months of September and May; sterile females in May, June, and July. Thus the breeding season seems to be normal.

The soft parts (of *iris* and *novi-eboraci*) have been described by Lea (Obs., X, 1863, p. 419) and Simpson (in Baker, 1898, p. 106).

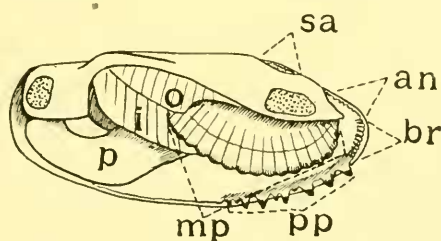


FIG. 23. *Eurynia (Micromya) iris* (Lea). Gravid female from Little Beaver Creek, Enon Valley, Lawrence Co., Pa. (Carn. Mus., No. 61, 2, 159.) Coll. May 11, 1907.

In front of the branchial (see Ortmann, 1911b, p. 317) there are four to ten large, conical papillæ, which are quite distant from each other, with a few smaller ones between them. They do not reach to the middle of the lower margin. Marsupium formed by the posterior half (or less) of the outer gill, with a very small non-marsupial section at the posterior end. Ovisacs thirteen to twenty-two. Edge of

marsupium with black pigment. Glochidia rather large, suboval (see Lea, Obs., VI, 1858, pl. 5, fig. 14, as *novi-eboraci*, and Ortmann, 1911b, pl. 89, fig. 20). Length 0.22; height 0.28 mm.

In all other respects like the foregoing species. Inner lamina of inner gills entirely connected, but in one case a small hole at posterior end of foot has been observed.

**Eurynia (Micromya) vanuxemensis (Lea).**

Two gravid females were donated by B. Walker. They are from Shoals Creek, Lauderdale Co., Alabama, and were collected by H. H. Smith on November 3, 1909.

On the inner edge of the mantle in front of the branchial there are ten to fifteen cylindro-conical, rather large papillæ, irregular in size, standing rather close together upon a slightly dilated part of the edge. This part is not very long, but longer than the branchial opening. Farther in front, the dilated part narrows suddenly, and becomes smooth. A rather broad black band accompanies the papillæ. The marsupium occupies one-half or a little more of the outer gills, with a very small non-marsupial section at the posterior end. Ovisacs large, nine to thirteen, their ends marked with brown pigment. Glochidia as usual in this group. Length 0.22; height 0.28 mm. (see Plate XX, fig. 6).

All the rest of the soft parts like those of the preceding species.

**Eurynia (Micromya) picta (Lea).**

Soft parts of two gravid females from the South Fork of the Cumberland River, Burnside, Pulaski Co., Kentucky, were received from B. Walker.

Upon the edge of the mantle in front of the branchial there are numerous, crowded, irregular, subconical papillæ. The posterior ones, close to the branchial, are small, and increase in size forward, then stop suddenly, and beyond this there are a few very small ones, until finally the edge of the mantle becomes smooth. The papillæ do not reach the middle of the lower margin. Marsupium formed by a little less than half of the outer gill, with a small non-marsupial section behind. Ovisacs ten to fourteen, with black pigment at ends. Glochidia as usual. Length 0.22; height 0.27 mm. (see Plate XX, fig. 7).

All other parts like those in the foregoing species.



**Eurynia (Eurynia) nasuta** (Say).

Numerous specimens have been investigated, partly from Lake Erie, partly from the Delaware drainage in eastern Pennsylvania and New Jersey.

According to Conner (1907, p. 88) this species breeds all the year round, that is to say, the end of one breeding season overlaps the beginning of the next in midsummer. This refers to the Delaware drainage in eastern Pennsylvania. For this region I have only a few observations (in the months of September and May). From Lake Erie I have specimens with eggs collected at the end of August (beginning the breeding season), and others with glochidia collected in May, June, and as late as July 7. On the latter date specimens in the act of discharging were observed. But there is surely an "interim" in Lake Erie, at least in July, for of all the specimens collected on July 8, 12, 22, and 23, not a single one was gravid, although numerous sterile females were among them.

The soft parts have been described by Lea (Obs., X, 1863, p. 403), but in error the marsupium is said to occupy the whole length of the gill. The papillæ of the edge of the mantle have been described by Ortmann (1911b, p. 317).

The inner edge of the mantle of the female has in front of the branchial a rather regular row of numerous (as many as thirty and more) rather closely set, subequal papillæ, which are rather small, subconical, and run forward to almost the middle of the ventral margin, where they disappear gradually and pass into the smooth anterior part of the edge. This row is not accompanied by a distinct black band, but there is brownish pigment in this region. Marsupium formed by over half (up to three-fourths) of the outer gills, with a very small non-marsupial section behind. Ovisacs fifteen to forty, their ends having no black pigment. Glochidia (Lea, Obs., XIII, 1874, pl. 21, fig. 2), similar in shape to those of the preceding species, rather large. Length 0.25; height 0.29 mm. (see Plate XX, fig. 8).

Mantle-connection between anal and supra-anal rather long, longer than the anal. Inner lamina of the inner gills connected with the abdominal sac, often with a small hole at the posterior end of the foot. Posterior margins of palpi connected only at base.

**Eurynia (Eurynia) subrostrata** (Say).

According to Lea's description (Obs., X, 1863, p. 439, glochidia XIII, 1874, pl. 21, fig. 1, as *nashvillensis*), and, relying principally upon the figure given by Lefevre and Curtis (1910, pl. 1, fig. 2), this species belongs here.

**Eurynia (Eurynia) recta** (Lamarck).

Numerous specimens from the Ohio drainage and Lake Erie in western Pennsylvania, from Ohio and Arkansas have been investigated.

Bradyctic. The breeding season begins about the middle of August, and ends unusually late, in July (latest date July 23). Specimens with fully developed glochidia have repeatedly been found in

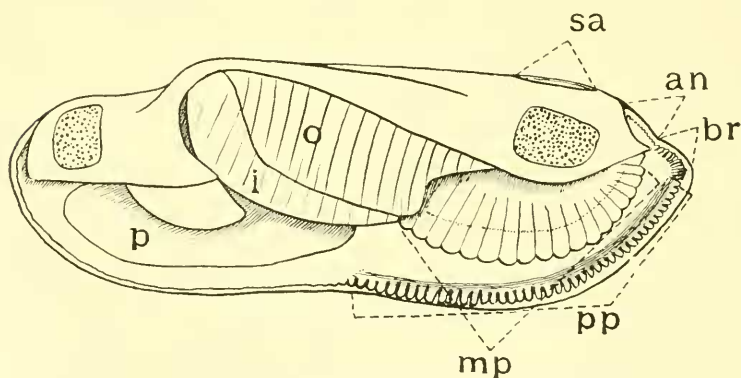


FIG. 24. *Eurynia (Eurynia) recta* (Lamarck). Gravid female, from Lake Erie, Cedar Point, Erie Co., O. (Carn. Mus., No. 61, 4,458.) Coll. August, 1909, by Chas. Brookover.

July, and for specimens with eggs the earliest date is August 13. Although there is apparently an interim of a few weeks, the seasons come very near to overlapping. But for single individuals there is very likely a longer interval between the breeding seasons, for sterile females are very frequent in August and September, and the majority do not become gravid till October. I cannot detect any difference in this matter in Lake Erie. At any rate, the beginning and end of the breeding season are not later than in the Ohio, in fact the latest date for the end (July 23) is from the Ohio drainage.

The soft parts have been discussed by Lea (Obs., X, 1863, p. 426)

and Simpson (in Baker, 1898, p. 102), and a figure of them has been published by Lefevre and Curtis (1910, pl. 1, fig. 5).

The inner edge of the mantle of the female in front of the branchial has (see Ortmann, 1911*b*, p. 318) a row of regular, rather crowded, subequal papillæ, which are large and conical, and run forward to about the middle of the ventral margin, where they disappear suddenly. The anterior part of the inner edge is smooth. The papillæ increase somewhat in size from the branchial forward, and the largest papillæ stand near the anterior end of the row. A distinct brownish black streak accompanies this row, and the papillæ have the same color at their bases, while they are whitish at their tips.

Marsupium occupying less than the half of the posterior section of the outer gill, with a very small non-marsupial section behind. Ovisacs fifteen to thirty, without black pigment at their ends. Glochidia (Lea, Obs., VI, 1858, pl. 5, fig. 11; Lefevre and Curtis, 1910, p. 97, fig. L; Ortmann, 1911*b*, pl. 89, fig. 21) as in the preceding species; I have found their length to be 0.22; height 0.28 mm.; while Lefevre and Curtis give length 0.20; height 0.24 mm.

In other respects like the last species, but inner lamina of inner gills always entirely connected, and mantle-connection between anal and supra-anal shorter than anal.

Genus *LAMPSILIS* Rafinesque. (1820.)

(Simpson, 1900*b*, p. 526 (restricted).)

Shell ovate to elliptical, or elongated. Outside of shell not sculptured. Beak-sculpture of the sinuated or double-looped type, finer or coarser, sometimes the posterior loop open behind, or the sculpture is obsolete. Epidermis generally yellowish or greenish, mostly rayed, often very beautifully so. Female shell quite distinct from that of the male, with a strong inflation and dilatation in the post-basal region, producing a distinct posterior truncation of the shell.

Inner lamina of inner gills entirely connected with abdominal sac, but sometimes a small hole is left at the posterior end of the foot. In the female, the edge of the mantle in front of the branchial is developed into a ribbon-like flap, generally produced anteriorly into a free, projecting lobe, which has a lacerated appearance. Along the edge of the flap, there may or may not be crenulations or teeth, but never real papillæ. On the inside, the flap is beautifully colored,



generally with a black streak, and often has a peculiar eye-spot at the posterior end, close to the branchial. In the male a similar structure is found in a rudimentary condition.

Marsupium kidney-shaped, swollen, formed by many ovisacs, occupying the posterior part of the outer gill. Edge of marsupium blunt, beaded, generally pigmented. Placentæ not solid. Glochidia subovate, rather large.

Type *L. ovata* (Say).

In the specialization of the edge of the mantle in front of the branchial this genus represents the highest type of *Lampsilinæ*.

### *Lampsilis anodontoides* (Lea).

I have one male and two gravid females from the Colorado and Rio Grande Rivers in Texas (D. A. Atkinson coll. May, 1907); five specimens (males and females) from Kansas River, Lawrence, Douglas Co., Kansas (R. L. Moodie); one young male and one gravid female from Ouachita River, Arkadelphia, Clark Co., Arkansas (H. E. Wheeler. coll. Feb. 6, 1911).

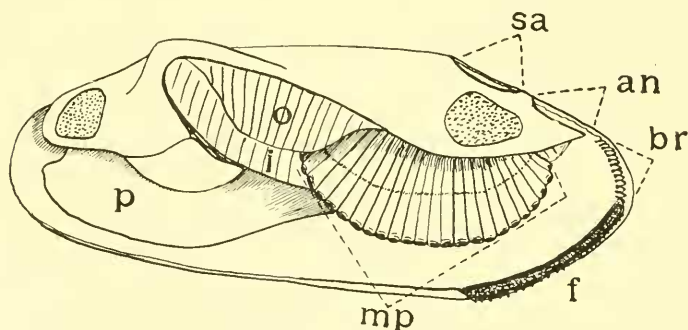


FIG. 25. *Lampsilis anodontoides* (Lea). Gravid female, from Rio Grande, Mercedes, Hidalgo Co., Tex. (Carn. Mus., No. 61, 2, 155.)

The gravid females all have glochidia, and show that the species is bradyctictic, carrying the larvæ over the winter.

The soft parts have been described by Lea (Obs., X, 1863, p. 406) and Simpson (in Baker, 1898, p. 101).

Mantle-connection between anal and supra-anal of medium length, shorter than the anal. Anal crenulated, branchial with papillæ. In front of the branchial the inner edge is in the female lamellar and dilated, forming a ribbon-like expansion, which is (in alcoholic speci-

mens) either merely suddenly truncated in front, or forms a small free lobe, variable in my more or less contracted specimens. Along its edge this expansion is crenulated, but has no papillæ, and the whole inner side of this flap is of a brownish black color, sometimes a distinctly brown streak between two black streaks is seen. No eye-spot has been observed. The flap extends over about one-third of the lower margin, and farther in front the inner edge of the mantle is smooth.

Posterior margins of palpi connected for about one-fourth of their length. Gills and diaphragm of usual shape and structure. Inner lamina of inner gills connected with abdominal sac.

Marsupium kidney-shaped, occupying about the posterior half of the outer gill, composed of numerous (about thirty) ovisacs. Margin of marsupium with blackish pigment. A very small section of the gill posteriorly is non-marsupial. Glochidia (Lea, Obs., VI, 1858, pl. 5, fig. 2) rather large, subovate. Length 0.20; height 0.26 mm. (see Plate XX, fig. 9).

Color of soft parts whitish, with little brown on the edge of the mantle, and the markings on the flap and the marsupium as described above.

According to the shape of the shell, this species was always supposed to be closely related to *Eurynia recta*, but I doubt whether there is actually a close relationship between these two species. The mantle-flap of *L. anodontoides* is entirely different from the papillæ of *E. recta*. However, in *L. anodontoides* the mantle-flap has not yet attained the typical development of the genus, and the anterior free end is in particular rather indistinct. Probably it is the most primitive form of *Lampsilis* and connects this genus with more *Eurynia*-like ancestors, but it cannot be placed in *Eurynia* on account of the lack of papillæ on the edge of the mantle.

#### ***Lampsilis fallaciosa* Smith.**

I have not seen the soft parts of this form, but I doubt very much whether it is specifically distinct from *L. anodontoides*. Among my specimens from Kansas River, there are some, to which this name might be applied. Among other material likewise in the Carnegie Museum I cannot sharply distinguish these two forms.

Simpson (1900a, p. 75) says: "in *L. fallaciosa* there is a horny, brown, raised streak on the inside of the mantle behind, that I do not find in *anodontoides*." This "streak," however, is also present in

*anodontoides* (my specimens from Texas are typical and undoubted *anodontoides*), and it is not at all "horny," and corresponds to the flap described above.

***Lampsilis luteola* (Lamarck).**

Many specimens from the Lake Erie and Ohio drainages in western Pennsylvania, and also from Kansas and Arkansas, have been investigated.

Bradyctictic, and may be found gravid practically all the year round. The breeding season begins at the beginning of August, and ends in July, and may overlap with the next toward the end of July. But in July there is an indication of an interim, gravid specimens being quite rare. In the Ohio drainage, the females have generally discharged their glochidia by the beginning of July, and only single belated individuals are met with later. In Lake Erie, discharging females were found more frequently in July, as late as July 12. No gravid females have ever been found between July 12 and August 4 by myself.

The soft parts have been described by Lea (Obs., X, 1863, p. 402) and Simpson (in Baker, 1898, p. 104).

Mantle-connection between anal and supra-anal of medium length, shorter than anal. Anal crenulated, branchial with papillæ. In front of branchial the female has on the inner edge of the mantle a typically developed flap (see Ortmann, 1911b, p. 321). It has the shape of a ribbon-like keel, with irregular, rather distant teeth, but no papillæ,<sup>53</sup> and its anterior end projects considerably, even when contracted, and has great powers of expansion. The marginal teeth are largest at the free lobe, which appears lacerated. There are a number of irregular teeth on the edge of the mantle in front of the lobe, but soon the edge becomes smooth. On the inner side of the flap there is a broad streak of black pigment. Eye-spot (in alcoholic material) indistinct. The flap extends over about one-third of the lower margin.

Posterior margins of palpi connected for about one-fourth of their length. Gills and diaphragm normal. Inner lamina of inner gills entirely connected, rarely a very small hole remaining at the posterior end of the foot.

Marsupium kidney-shaped, occupying about the posterior half of

<sup>53</sup> When strongly contracted by the action of alcohol, the teeth become thicker, and appear like papillæ, but when expanded, they are flat (not sub-cylindrical).

the outer gill, with a very small posterior non-marsupial section. Ovisacs numerous, fifteen to forty, or more. Margin of marsupium with black pigment. Glochidia (Lea, Obs., VI, 1858, pl. 5, fig. 10) rather large, suboval. Length 0.23; height 0.28 mm.

Color of soft parts whitish, foot more yellowish, gills white to brownish. Margin of mantle blackish posteriorly. Color of flap and marsupium as mentioned above.

#### **Lampsilis radiata** (Gmelin).

I have not seen more than half a dozen specimens, and among them only one gravid female with eggs, but no glochidia (August 22). They were all from the Susquehanna drainage in Pennsylvania.

According to Conner (1907, p. 88, and 1909, p. 112) this species breeds "all the year round," but the conditions probably will prove to be the same as in *L. luteola*. The beginning of the breeding period is indicated by my specimen.

The soft parts agree in all essential respects with those of *L. luteola*. They have been figured by Lea (Obs., II, 1838, pl. 15, fig. 48 and 49), but fig. 48 does not represent the typical shape of the flap.

The glochidia have been figured by Lea (Obs., VI, 1858, pl. 5, fig. 20).

#### **Lampsilis claibornensis** (Lea).

Two males and two gravid females, Pearl River, Jackson. Hinds Co., Mississippi, A. A. Hinkley coll., Nov. 4, 1910.

Soft parts absolutely identical with those of *L. luteola*. Glochidia: length 0.21; height 0.27 mm.

The glochidia have been figured by Lea as *obtusus* (Obs., VI, 1858, pl. 5, fig. 1), and as *claibornensis* (Obs., XIII, 1874, pl. 21, fig. 9). The same author (Obs., X, 1863, p. 406) says of *obtusus* (= *claibornensis*) that it "has large dark papillæ below the branchial opening." This is not so in my specimens, which have the typical *luteola*-flap. Lea's description of *claibornensis* (*ibid.*, p. 436) is better.

#### **Lampsilis hydiana** (Lea).

Three gravid females, Bayou Pierre, De Soto Parish, Louisiana. L. S. Frierson coll., August 6, 1910.

One of these has eggs, indicating the beginning of the breeding season; the other two have glochidia, and one of these has the marsupium only partly charged, possibly discharged in part. This



apparently indicates the over-lapping of the seasons in this species also.

The description of the soft parts given by Lea (Obs., XIII, 1874, p. 72) is very incomplete. But judging from the specimens before me they are absolutely identical with those of *L. luteola*. Glochidia: length 0.21; height 0.27 mm. (see Plate XX, fig. 10).

***Lampsilis ovata* (Say).**

The soft parts of about half a dozen specimens have been preserved, but many more have been examined in the field. They were all from the Ohio drainage in Pennsylvania.

Gravid females have been found in August, September, and October.

Lea (Obs., X, 1863, p. 435) describes the soft parts.

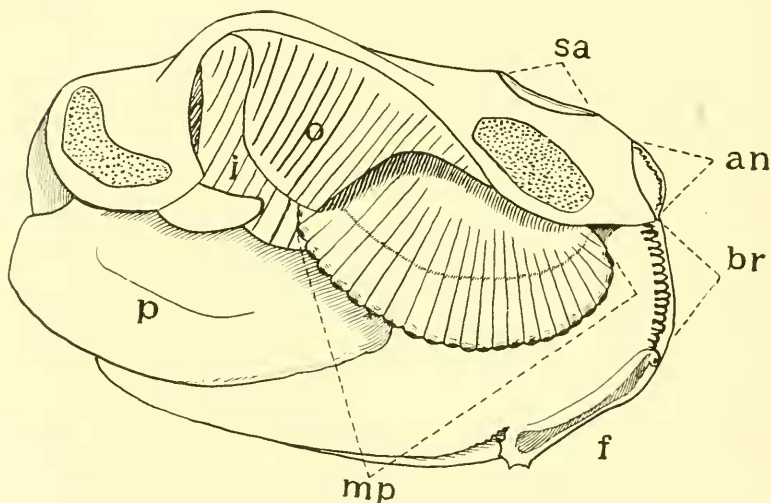


FIG. 26. *Lampsilis ovata* (Say). Gravid female, from Allegheny River, Kelly, Armstrong Co., Pa. (Carn. Mus., No. 61, 2,997.) Coll. Sept. 27, 1907.

The flap in front of the branchial opening is greatly developed. When contracted, it has only a rounded, toothed lobe at the anterior end. But when expanded (see figure of *L. ventricosa*, Ortmann, 1911b, p. 320, fig. 8) it is much longer. The edge of the lamellar expansion is practically smooth, but the free lobe has irregular teeth. An eye-spot is present at the posterior end, but this is indistinct in the contracted condition. Anterior to the free lobe the inner edge of the mantle is slightly crenulated, and then smooth.

Mantle-connection, anal, branchial, and gills like those of *L. luteola*. Inner lamina of inner gills entirely connected, or with a small hole at posterior end of foot. Posterior margins of palpi connected for one-third, or slightly more, of their length.

Marsupium occupying the posterior half (more or less) of the outer gill, greatly swollen, kidney-shaped, with pigment on margin. Ovisacs numerous, up to thirty or more. Glochidia (figured by Lea, Obs., VI, 1858, pl. 5, fig. 15)<sup>51</sup> large, subovate; length 0.24, height 0.28 mm.

Color of soft parts like that of *L. ventricosa*, generally paler, with the orange tints prevailing on the margin of the mantle and flap. Black line on inside of flap sometimes wanting.

### ***Lampsilis ventricosa* (Barnes).**

Numerous specimens have been investigated from western Pennsylvania, and a gravid female from Hurricane Creek, Gurley, Madison Co., Alabama (H. E. Wheeler coll., Sept. 13, 1910).

Bradyctictic; the breeding season commencing at the beginning of August, and ending in July, so that the species is gravid "all the year round," with the seasons possibly slightly overlapping in July. But the majority of the females discharge their glochidia in May and June, and in July only a few belated ones are found. The Lake Erie form (*canadensis* Lea) has about the same breeding season, but gravid females were not found in July.

The soft parts have been described (as *occidens*) by Lea (Obs., X, 1863, p. 418), and Simpson (in Baker, 1898, p. 95). The flap of the mantle has been figured rather well by Lea (Obs., VII, 1860, pl. 30, fig. 107) and by Ortmann (1911b, pp. 319 and 320, figs. 7 and 8). The anatomy is in every respect like that of *L. ovata*, of which this is probably only a variety.

Color grayish white, gills pale brownish, foot pale yellow or brown. Marsupium white, with black edge. Margin of the mantle mottled black and brown, the brown often shading to orange. Mantle-flap gray on outside, inside pale orange or brownish, with a black longitudinal line, and an eye-spot (black in white field) at posterior end.

<sup>54</sup> Here again a mistake occurs in Lea's figures. In fig. 13 of the same plate he figures the glochidium of *occidens* (= *L. ventricosa*), and the latter is considerably larger than that of *L. ovata*. The fact is, however, that the glochidia of these two forms are practically indistinguishable in size and shape, and the slight differences in our measurements may easily be regarded as matters of personal equation in the case of the observer.

Glochidia (Lea, Obs., VI, 1858, pl. 5, fig. 13, as *occidens*, and Ortman, 1911b, pl. 89, fig. 23): length 0.25; height 0.29 mm.

**Lampsilis excavata** (Lea).

Two males, Pearl River, Jackson, Hinds Co., Mississippi (A. A. Hinkley).

Structure of soft parts as in the foregoing species. Since no females are at hand, the shape of the mantle-flap, the marsupium, and glochidia could not be ascertained, but the latter have been figured by Lea (Obs., XIII, 1874, pl. 21, fig. 6). My two males have a rudimentary mantle-flap, consisting of a narrow lamellar keel, with a black streak on the inside, ending anteriorly in a short, angular projection. This is similar to the males of *L. ovata* and *ventricosa*. The posterior margins of the palpi are united for from one-third to one-half of their length.

This form undoubtedly falls into the same group with the foregoing species.

**Lampsilis multiradiata** (Lea).

Six males and six females (three gravid) are at hand, from the Ohio drainage of western Pennsylvania.

Breeding season probably as in the preceding species; in fact I have found gravid females in May, June, July, August, September, and October. Discharging females were found as late as August 9.

Females with eggs were secured in the beginning of September. Thus it seems that the seasons overlap later than in *L. luteola* and *ventricosa*, in August.

Soft parts (described by Lea, Obs., X, 1863, p. 426, and Simpson, in Baker, 1898, p. 96) absolutely identical with those of *L. ovata* and *ventricosa*, only there are a number of teeth along the edge of the flap. Colors also similar, but the orange on the margin of the mantle and flap prevalently very bright. Glochidia (Lea, Obs., VI, 1858, pl. 5, fig. 17): length 0.25; height 0.29 mm.

**Lampsilis cariosa** (Say).

Four males and four females (two gravid) from the Susquehanna and Delaware drainages in eastern Pennsylvania. Many more investigated in the field.

The breeding season begins in the first half of August. In 1910, I was unable to find any gravid females on August 7, in the Susque-

hanna at York Haven, while on August 14, at Selinsgrove, they were frequent, but had only eggs. Conner's notes (1909, p. 112) are unreliable, for he has confounded this species with *L. ochracea*, as I discovered from specimens he sent to me. He gives for *ochracea* (which would be this species) that it is gravid in April, May, and June. My observations are incomplete, but there seems to be an interim at least at the beginning of August. Perhaps the conditions are similar to those in the allied species.

Lea's figure (Obs., II, 1838, pl. 15, fig. 45) of the soft parts is entirely useless, but the soft parts agree fully with the preceding species. The color is much like *L. ventricosa*, but the margin of the mantle and inner side of the flap are generally of a beautiful chestnut tint. Black line on flap sometimes wanting.

I have only one specimen with glochidia, and even in this they are too young to be correctly measured. But they seem to have the general shape and size of those of the foregoing species.

#### ***Lampsilis orbiculata* (Hildreth).**

Three females, two of them gravid, from the Ohio River in Beaver Co., Pennsylvania, have been examined.

This species was found gravid with eggs in August (10 and 24), and with glochidia in September, and thus the beginning of the season agrees with that of the other species of this genus.

Although this species is placed by Simpson close to *L. ligamentina*, it is not at all related to the latter, which is a *Nephronajas*, while this is a true *Lampsilis*, as is shown by the presence of a typical flap (Ortmann, 1911b, p. 321). This flap has numerous teeth along its edge, and projects at the anterior end in a free lobe. It also has black pigment on the inside. An eye-spot has not been seen, but this may be obscured on account of the contracted condition of my specimens.

All the rest of the soft parts are like those of the foregoing species. The glochidia (Ortmann, 1911b, pl. 89, fig. 22) are peculiar in so far that I have on my slides two sizes of them. The smaller is more frequent, length 0.19; height 0.21 mm., and among them are rather rarely larger ones, length 0.20; height 0.25 mm. No intergrades seem to be present. It is not entirely impossible that by some accident in making the slide, the glochidia of another species have become mixed with this one, but this is not very likely. There are no glochidia having the dimensions of the larger ones, except those of *L. anodontoides*.

## Genus TRUNCILLA Rafinesque. (1819.)

Simpson, 1900b, p. 516.

Shell subovate, inflated, often subtriangular, and with a strong posterior ridge or radiating furrow. Outside of shell not sculptured or only with low tubercles. Beak-sculpture delicate, often obsolete, double-looped. Epidermis yellowish greenish, rayed, rays often broken. Shell of the female very distinct from that of the male, with a strong inflation or projection in the post-basal region, which changes the outline of the shell considerably, very often giving the latter odd shapes. In the region of this inflation, the shell often becomes horny, or its margin is toothed.

Inner lamina of inner gills entirely connected with abdominal sac. In the female, the inner edge of the mantle in front of the branchial is not parallel to the outer edge, but is more or less remote from it, often quite distant, and it has finer or coarser papillæ. Toward the middle of the lower margin, the two edges again approach each other, and are normal farther forward. The mantle between the two edges is peculiarly spongy. Thus an inner compartment is formed in front of the branchial opening. In the male, the two edges of the mantle do not have this structure, or it is only merely indicated.

Marsupium swollen, kidney-shaped, formed by many ovisacs, occupying the posterior section of the outer gill. Edge of marsupium blunt, beaded, but not pigmented. Placentæ not solid. Glochidia differing from those of *Eurynia* and *Lampsilis*, being of medium size, almost semicircular, and about as long as high.

Type *T. triquetra* Rafinesque.

The peculiar compartment formed inside in front of the branchial certainly is connected with the care of the glochidia, and possibly is to be regarded as something like a water-reservoir. This is the most highly specialized type of the *Lampsilinæ*, but it is a side branch, probably not descended from *Eurynia*- or *Lampsilis*-like forms, but from a more primitive type. The development of the inner compartment has influenced the shape of the female shell greatly and has, so to speak, deformed it, and in this genus we have represented the greatest dimorphism between the shells of the male and the female, which occurs.

Walker (1910c) recently has given a synopsis of the species of the genus, and divides, them, according to the shell, into three groups:

(1) those with the entire post-basal area occupied by the marsupial expansion; (2) those with the marsupial expansion restricted to the posterior ridge; (3) those with the marsupial expansion in front of the posterior ridge. These divisions undoubtedly are natural, and Walker thinks that the first represents the most primitive condition,<sup>55</sup> from which the other two are to be derived.

Having regard to the shell only, this view is quite plausible, but in studying the structure of the soft parts, it becomes evident, that it is scarcely tenable. Although I have seen comparatively few species, it is certain that the simplest structure is found in *T. triquetra*, which represents the second group of Walker. In this species the typical features of the genus are barely indicated. From this form we can imagine that the other two have been derived, and have descended in apparently two parallel lines; in the one (represented by *T. haysiana* in our material), the marsupial swelling advances forward from the posterior ridge, in the other (represented by *rangiana*, *florentina* and *capsaformis*) it becomes greatly enlarged, and often corneous. In the latter forms, the inner compartment of the soft parts is most capacious, and developed to its greatest extent, and consequently these must be the most advanced types within the genus. (Possibly, however, some of the third type may be as highly specialized, but in another direction.)

### ***Truncilla triquetra* Rafinesque.**

Twelve males, two sterile, and seven gravid females are at hand, from the Ohio drainage in western Pennsylvania.

The gravid females were found in September and October, but further details as to the breeding season are not known.

The soft parts have been described by Lea (Obs., X, 1863, p. 420). (See also Ortmann 1911b, p. 321.)

Anal and supra-anal separated by a mantle-connection of medium length, but shorter than the anal. Anal with fine crenulations, branchial with papillæ, which stand somewhat remote from the outer edge. The latter is, corresponding to the teeth on the margin of the shell, toothed or scalloped. In the female, the inner edge of the

<sup>55</sup> He compares the general shape of the shell with the female of *Lampsilis*, and thinks that it is closely allied to it. I rather believe, that the roots of *Truncilla* are to be sought in forms which stood between *Amygdalonajas* and *Eurynia*. Some characters of the shell resemble strongly those of *Amygdalonajas*.

mantle in front of the branchial is also somewhat distant from the toothed outer edge, and bears four to ten, rather distant, subconical, small papillæ, which are smaller than the papillæ of the branchial, and decrease in size forward. Along this part of the edge runs a black streak, and the papillæ also are black or brown. The space between the two edges is blackish-brown, lighter toward the outer edge. Before the middle of the lower margin is reached, the two edges approach each other, and thence forward are normal, the inner one smooth. In the male, the two edges are subparallel and close together, as is normal, and there are only a few small papillæ in front of the branchial.

Posterior margins of palpi connected at base only. Gills and diaphragm of normal structure. Inner lamina of inner gills entirely connected with abdominal sac.

Marsupium formed by over half of the posterior part of the outer gill, with hardly any non-marsupial part behind, greatly swollen,

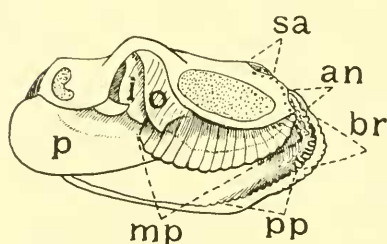


FIG. 27. *Truncilla triquetra* Rafinesque. Gravid female, from Allegheny River, Aladdin, Armstrong Co., Pa. (Carn. Mus., No. 61, 3,358.) Coll. Sept. 18, 1908.

kidney-shaped, higher in front than behind, and slightly deformed to suit the shape of the shell, presenting a broad face outwardly and downwardly, and having a blunt edge toward the median line of the animal, where the two marsupia come into contact. Margin of marsupium without pigment. Ovisacs numerous, thirty to forty. Glochidium of medium size, almost semicircular; length and height

0.21 mm. (See Ortmann, 1911b, pl. 89, fig. 24; Lea's figure, Obs., VI, 1858, pl. 5, fig. 19, is not correct.)

Color of soft parts whitish. Margin of the mantle with black spots in the posterior parts, black inside of the branchial opening, and with black streak in front of the latter, farther in front brown.

The characteristic structure of the inner edge of the mantle is very poorly developed in this species, and if it were not for the other species, its significance would hardly be realized. Nevertheless, according to shell characters, this is a true *Truncilla* (being besides the type).



**Truncilla haysiana** (Lea).

Four males, one sterile, and one gravid female have been received from B. Walker, they are from the Cumberland River in Kentucky.

Agrees in every particular with *T. triquetra*, with exception of the inner edge of the mantle in front of the branchial in the female. Here the papillæ of the branchial are not markedly distant from the outer edge, but in front of them the inner and outer edges of the mantle diverge considerably, both describing a short curve in opposite directions, coming together again before they reach the middle of the ventral margin. They enclose a lanceolate or broadly ovate space of spongy structure and black-brown in color. The inner edge has four to six distinct papillæ in its anterior part, which are brown. Back of them, toward the branchial, lies upon the edge a very remarkable, pure white caruncle, which, in the alcoholic material at hand, is rounded, without distinct shape or structure except a few crenulations. Inside of the inner edge runs a black streak. The color of the mantle around the branchial papillæ and forward along the edge is dark black and brown, and thus the caruncle is sharply marked off by its color. Anteriorly the margin of the mantle is brown, and in the region of the anal and supra-anal it is spotted with brown. In the male the two edges of the mantle are very little distant from each other, the inner has small papillæ, one of which is pure white, but is much smaller than the corresponding caruncle of the female.

Marsupium more regularly kidney-shaped, than in *T. triquetra*. Glochidia similar, but larger; length 0.24; height 0.23 mm. (see Plate XX, fig. 11).

**Truncilla penita** (Conrad).

This species, which, according to Walker (1910c, p. 77), belongs to the *triquetra*-group, has been described by Lea (Obs., X, 1863, p. 440). It has below the branchial "a small white fleshy mass . . . of a sub-sigmoid form, rounded at the bottom, and pointed at the top, and furnished with some crenulations in the middle." There is no doubt that this mass is similar and homologous to the white caruncle described above in *T. haysiana*. I have not seen anything like it in *T. triquetra*. But the presence of this organ, the function of which is unknown to me, serves to connect more closely the two groups to which *T. triquetra* and *haysiana* belong.

*Truncilla rangiana* (Lea).

Six males, four sterile and four gravid females, from the upper Allegheny River drainage in Pennsylvania, are at hand.

The gravid females, with eggs and glochidia, were found in September.

This form is generally regarded as a variety of *T. perplexa*, but Walker (1910c) separates it as a species. All specimens examined by me are true *rangiana*, but they do not agree with the characters given in Walker's key (*l. c.*, p. 80), since the color and texture of the marsupial expansion is, in old females, quite different from the rest of the shell, being horny and lacking in lime. In young females, this is not the case.

As to the soft parts, see Ortmann (1911b, p. 322), and also those of *perplexa*, described by Lea (Obs., X, 1863, p. 420).

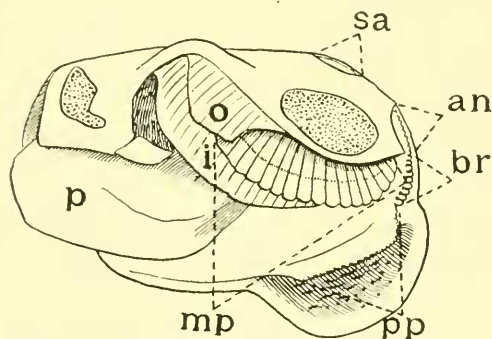


FIG. 28. *Truncilla rangiana* (Lea). Gravid female, from French Creek, Cochran-ton, Crawford Co., Pa. (Carn. Mus., No. 61, 3,363.) Coll. Sept. 2, 1908.

Anal, supra-anal, palpi, structure of gills, and marsupium generally as in *T. triquetra*. The marsupium is greatly swollen, rather low and long, not so much deformed. Glochidia (figured as of *perplexa* by Lea, Obs., VI, 1858, pl. 5, fig. 21) are also similar; length 0.26; height 0.23 mm., but my measurements are not very accurate, since all the glochidia I have are very young and delicate.

In the female, the two edges of the mantle diverge greatly in front of the branchial, the outer one curving outward, and forming a great, almost semicircular lobe, with a smooth edge; while the inner one runs almost straight downward and forward; the two edges coming together

again at about the middle of the lower margin. The inner edge has crowded, very fine papillæ, which decrease anteriorly, and the anterior part of the edge is smooth. The space between the two edges is of a peculiar spongy structure, full of what appear as finely rounded or elongated pores.

In the male the two edges of the mantle are subparallel and close together, as usual, and the inner one has very minute papillæ.

The color of the soft parts is generally whitish or yellowish white. Outer edge of mantle grayish posteriorly, in the region of the anal and supra-anal blackish, not spotted. Papillæ of branchial brown, but this color does not run forward along the inner edge, and the inner edge itself and the spongy space between the two edges is snow-white.

#### ***Truncilla florentina* (Lea).**

One gravid female has been received from B. Walker. It is from Shoals Creek, Lauderdale Co., Alabama, collected Nov. 2, 1909, by H. H. Smith.

Soft parts practically identical with those of *T. rangiana*, but the color of the margin of the mantle is different. Here both edges of the mantle are black-brown all around, and the space between the two edges is deep black. There is also in this region a deep black streak on the inside of the inner edge. The outer edge is slightly scalloped, corresponding to the dentate margin of the shell. In the specimen at hand, the spongy space is covered with numerous low granules, which I do not see in *T. rangiana*.

Glochidia like those of the other species; length 0.23; height 0.22 mm. (see Plate XX, fig. 12).

In this species also the post-basal expansion is somewhat different in texture from the rest of the shell, contrary to Walker's statement. It resembles very closely the structure seen in *T. capsæformis*.

#### ***Truncilla capsæformis* (Lea).**

One male and one sterile female, received from B. Walker, from the South Fork of Cumberland River, Burnside, Pulaski Co., Kentucky, are at hand.

Soft parts essentially those of *T. rangiana* and *florentina*, and in color agreeing with those of *T. florentina*, although the streak of pigment on the inside of the inner edge of the mantle is absent. There are also low granules upon the spongy space, but they are finer



than in *T. florentina*. The inner edge scarcely shows papillæ, but this may be due to lack of development or to the state of preservation of the specimens. The outer edge is slightly wavy, but has no teeth.

Charged marsupium not observed, but the marsupium is indicated in the sterile female by a series of white beads along the posterior half of the edge of the outer gill.

In the male the two edges of the mantle are subparallel and only slightly distant from each other, and posteriorly the color of the margin of the mantle consists of black spots, which are hardly noticeable in the female.

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There remains the Family *Mutelidæ*, with its two subfamilies (see above, p. 225) to be treated. My studies on these have been previously published (Ortmann, 1911a), and are yet rather incomplete. Since I have not investigated additional material, I cannot add anything to these preliminary results, and do not need to repeat them here. But my next undertaking will be to study the South American material of this family belonging to the Carnegie Museum, and these investigations will be published in due time.

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## EXPLANATION OF PLATE XVIII.

*Anatomy of Najades: sections of gills.*

Photographed with Bausch & Lomb Objective, 32 mm.

FIG. 1. *Quadrula lachrymosa* (Lea). Sterile female.—Ohio River, St. Marys, Pleasants Co., W. Va., coll. Sept. 20, 1910.—Carn. Mus., No. 61, 4,541. Horizontal cross section through left inner (*i*) and outer (*o*) gill, showing marsupial structure in both gills.

FIG. 2. *Pleurobema riddelli* (Lea). Sterile female.—Pearl River, Jackson, Hinds Co., Miss., A. A. Hinkley coll., Nov. 5, 1910.—Carn. Mus., No. 61, 4,963. Horizontal cross section through left inner (*i*) and outer (*o*) gill, showing marsupial structure only in outer gill.



FIG. 3. *Unio pictorum* (Linnaeus). Male—Moschinska River, Prov. Posen, Germany, W. Israël don.—Carn. Mus., No. 61, 4,938. Horizontal cross section through left inner (*i*) and outer (*o*) gill, showing gill structure of the male.

FIG. 4. *Unio pictorum* (Linnaeus). Sterile female.—Lake Storkow, Prov. Brandenburg, Germany, W. Israël don.—Carn. Mus., No. 61, 4,939. Horizontal cross section through left inner (*i*) and outer (*o*) gill, showing marsupial structure in outer gill only.

FIG. 5. *Unio crassus consentaneus* (Rossmessler). Sterile female.—Danube River, Buda-Pest, Hungary, W. Israël don.—Carn. Mus., No. 61, 4,996. Horizontal cross section through left inner (*i*) and outer (*o*) gill, showing marsupial structure in the outer gill only. (This section is more toward the base of the gills than in Fig. 4.)

FIG. 6. *Arcidens confragosus* (Say). Sterile female.—Bayou Pierre, De Soto Par., La., L. S. Frierson coll.—Carn. Mus., No. 61, 4,701. Horizontal cross section through left outer gill, showing marsupial structure of the sterile female, with indications of the places of the lateral water-tubes.

FIG. 7. *Anodonta cygnea* (Linnaeus). Sterile female.—Obra South Canal, Sepno, Prov. Posen, Germany, W. Israël don.—Carn. Mus., No. 51, 4,956. Horizontal cross section through left inner (*i*) and outer (*o*) gill, showing marsupial structure of the sterile female in the outer gill.

FIG. 8. *Anodonta cygnea* (Linnaeus). Gravid female.—Mogelnitz River, Prov. Posen, Germany, W. Israël don.—Carn. Mus., No. 61, 4,953. Horizontal cross section through left outer gill (marsupium), being partially filled with ova, and showing the beginning of the formation of the lateral water-tubes by folds arising from the septa.

FIG. 9. *Anodonta complanata* Rossmessler. Gravid female.—Woernitz River, Dinkelsbuehl, Bavaria, Germany, W. Israël don.—Carn. Mus., No. 61, 4,958. Horizontal cross section through left inner (*i*) and outer (*o*) gill, showing character of the marsupium in the outer gill, charged with glochidia. The lateral water-tubes are somewhat irregular in this specimen, the marsupium being only partly filled.

FIG. 10. *Obliquaria reflexa* Rafinesque. Gravid female, partly discharged.—Bayou Pierre, De Soto Par., La., L. S. Frierson coll. Aug. 6, 1910.—Carn. Mus., No. 61, 4,755. Vertical cross section through a discharged ovisac of the right marsupium, showing opening at its distal end.

FIG. 11. *Dromus dromas* (Lca). Gravid female.—Cumberland River, Rowena, Russell Co., Ky., B. Walker don.—Carn. Mus., No. 61, 4,969. Horizontal cross section through marsupial part of left outer gill, showing arrangement of the placenta and the glochidia.

#### EXPLANATION OF PLATE XIX.

##### *Glochidia of Najades.*

Photographed with Bausch & Lomb Objective,  $\frac{3}{8}$  inch.

FIG. 1. *Elliptio complanatus* (Dillwyn).—Meniolagomeka Creek, Smith Gap, Monroe Co., Pa., coll. June 14, 1910.—Carn. Mus., No. 61, 4,631.

FIG. 2. *Anodonta cygnea* (Linnaeus).—Moschinska River, Prov. Posen, Germany, W. Israël don.—Carn. Mus., No. 61, 4,954.



FIG. 3. *Anodonta complanata* Rossmæssler.—Danube River, Buda-Pest, Hungary, W. Israël don.—Carn. Mus., No. 61, 4,999.

FIG. 4. *Alasmidonta minor* (Lea).—Cumberland River, Pineville, Bell Co., Ky., B. Walker don.—Carn. Mus., No. 61, 4,977.

FIG. 5. *Ptychobranchius subtentus* (Say).—Cumberland River, Burnside, Pulaski Co., Ky., B. Walker don.—Carn. Mus., No. 61, 4,971.

FIG. 6. *Cyprogenia irrorata* (Lea).—Cumberland River, Albany Landing, Cumberland Co., Ky., B. Walker don.—Carn. Mus., No. 61, 4,973.

FIG. 7. *Dromus dromas* (Lea).—Cumberland River, Eadsville, Wayne Co., Ky., B. Walker don.—Carn. Mus., No. 61, 4,968.

FIG. 8. *Friersonia iridella* (Pilsbry and Frierson).—Valles River, Valles, San Luis Potosi, Mexico, A. A. Hinkley, coll. Dec., 1906—Jan., 1907.—Carn. Mus., No. 61, 4,495.

FIG. 9. *Obovaria retusa* (Lamarck).—Ohio River, Portland, Meigs Co., O., coll. Sept. 22, 1910.—Carn. Mus., No. 61, 4,773.

FIG. 10. *Obovaria unicolor* (Lea).—Pearl River, Jackson, Hinds Co., Miss., A. A. Hinkley coll. Nov. 5, 1910.—Carn. Mus., No. 61, 4,929.

FIG. 11. *Obovaria (Pseudoön) ellipsis* (Lea).—Ohio River, Portsmouth, Scioto Co., O., coll. Sept. 24, 1910.—Carn. Mus., no. 61, 4,777.

FIG. 12. *Nephronajas perdix* (Lea).—South Fork Cumberland River, Burnside, Pulaski Co., Ky., B. Walker don.—Carn. Mus., No. 61, 4,985.

The scale at the bottom of the plate represents one millimeter divided into tenths.

#### EXPLANATION OF PLATE XX.

##### *Glochidia of Najades.*

Photographed with Bausch & Lomb Objective,  $\frac{2}{3}$  inch.

FIG. 1. *Obliquaria reflexa* Rafinesque.—Bayou Pierre, De Soto Par., La., L. S. Frierson coll. Aug. 6, 1910.—Carn. Mus., No. 61, 4,755.

FIG. 2. *Proptera laevissima* (Lea).—Kansas River, Lawrence, Douglas Co., Kan., R. L. Moodie don.—Carn. Mus., No. 61, 4,481.

FIG. 3. *Medionidus conradicus* (Lea).—South Fork Cumberland River, Burnside, Pulaski Co., Ky., B. Walker don.—Carn. Mus., No. 61, 4,989.

FIG. 4. *Eurynia (Micromya) trabalis* (Conrad).—Cumberland River, Rowena, Wayne Co., Ky., B. Walker don.—Carn. Mus., No. 61, 4,990.

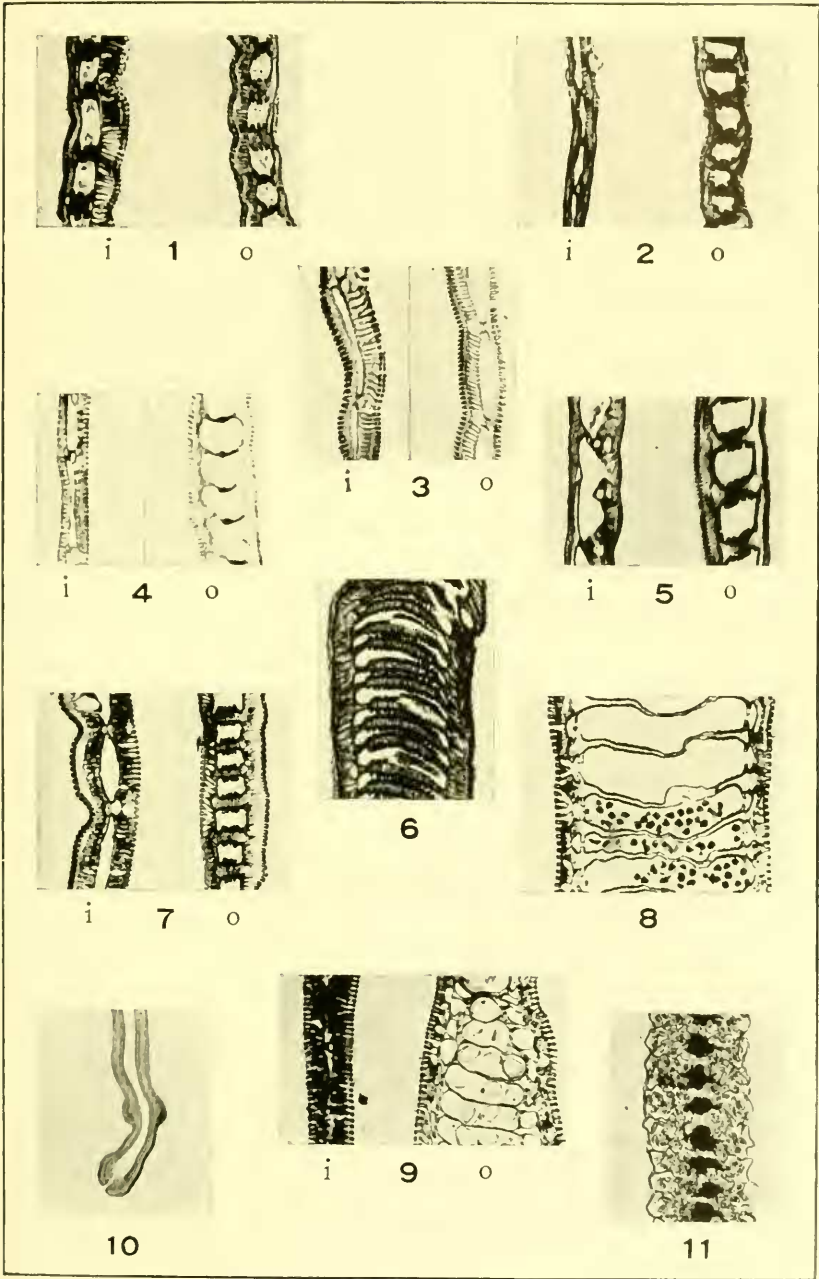
FIG. 5. *Eurynia (Micromya) lienosa* (Conrad).—Pearl River, Jackson, Hinds Co., Miss., A. A. Hinkley coll. Nov. 5, 1910.—Carn. Mus., No. 61, 4,930.

FIG. 6. *Eurynia (Micromya) vanuxemensis* (Lea).—Shoals Creek, Lauderdale Co., Ala., H. H. Smith coll. Nov. 3, 1909.—Carn. Mus., No. 61, 4,492.

FIG. 7. *Eurynia (Micromya) picta* (Lea).—South Fork Cumberland River, Burnside, Pulaski Co., Ky., B. Walker don.—Carn. Mus., No. 61, 4,995.

FIG. 8. *Eurynia nasuta* (Say).—Lake Erie, Presque Isle Bay, Erie Co., Pa., coll. June 3, 1908.—Carn. Mus., No. 61, 3,264.

FIG. 9. *Lampsilis anodontoides* (Lea).—Colorado River, Bay City, Matagorda Co., Tex., D. A. Atkinson coll. May 20, 1907.—Carn. Mus., No. 61, 2,157.



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